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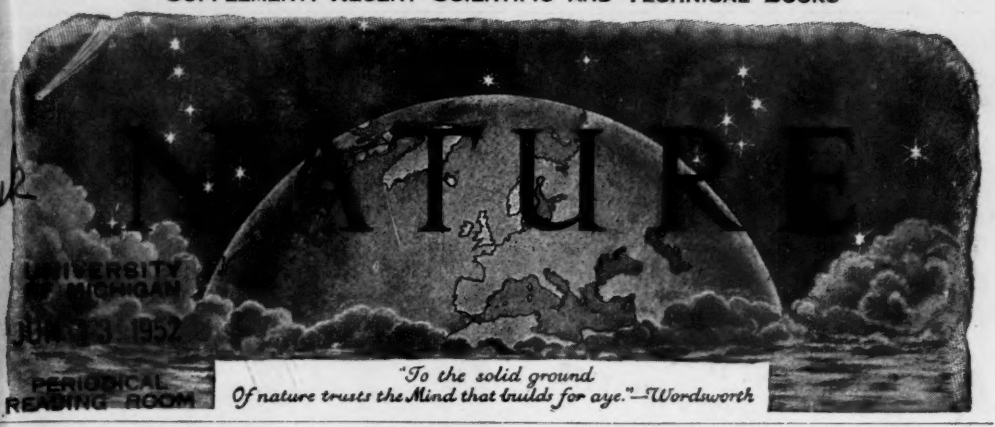


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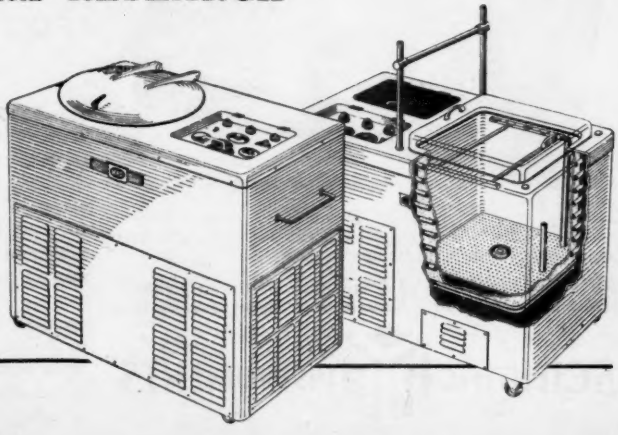

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No. 4309 SATURDAY, MAY 31, 1952 Vol. 169


## CONTENTS


| | Page |
|---|---|
| National Parks in Britain and their Control | 893 |
| Chemical Activities of the Protozoa. By Dr. C. A. Hoare, F.R.S. | 895 |
| South African Plants. By A. A. Bullock | 896 |
| An American View on Civil Defence. By J. W. Martin | 897 |
| The Rhythm of Reproduction. By Prof. S. Zuckerman, C.B., F.R.S. | 898 |
| The University of Southampton. By Prof. N. K. Adam, F.R.S. | 899 |
| Prestressed Concrete. By O. J. Masterman | 901 |
| Soft Magnetic Materials in Telecommunications | 905 |
| Obituary: Sir Charles Inglis, O.B.E., F.R.S. By Prof. E. B. Moullin | 906 |
| News and Views | 908 |
| Resonance in Gyro-interaction of Radio Waves. By Prof. V. A. Bailey, R. A. Smith, K. Landecker, A. J. Higgs and F. H. Hibberd | 911 |
| Morphology of Crystallizing Polymers. By A. Keller | 913 |
| Technological Education | 914 |
| Documentation Techniques in the United States | 915 |
| Mechanical Properties of Plastics. By Dr. N. J. L. Megson | 916 |
| Chemical Engineering at the Cross-roads | 917 |
| Technology and the History of Man | 918 |
| British Hydromechanics Research Association: Report for 1951 | 918 |
| International Statistical Institute: Conferences in India. By H. Home | 919 |
| Letters to the Editors: Structure of the Synthetic Polypeptide Poly-γ-methyl-L-glutamate.—Harry L. Yakel, jun., Prof. Linus Pauling, For.Mem.R.S., and Prof. Robert B. Corey | 920 |
| Composition of Silk.—Dr. F. Happey and A. J. Hyde | 921 |
| Energetics of Peptide Formation.—Prof. J. W. Breitenbach, J. Derkosch and F. Wessely | 922 |
| A New Method for the Detection of Peptides and Similar Compounds on Paper Chromatograms.—Dr. H. N. Rydon and P. W. G. Smith | 922 |
| A Technique for the Identification of Amino-Acids separated by Circular Paper Chromatography.—Dr. K. V. Giri and N. A. N. Rao | 923 |
| Double Zoning and the Homogeneity Test in Column Chromatography.—T. C. J. Ovenston | 924 |
| 'Elastic' and 'Plastic' Hardness of Hard Materials.—P. Grodzinski | 925 |
| A New Theorem in the Classical Theory of Elasticity.—Dr. A. S. Lodge | 926 |
| Holes in Crystals.—F. H. Horn, E. F. Fullam and J. S. Kasper | 927 |
| Hydrolysis of Casein with Sulphur Dioxide.—J. Wismer Pedersen and Dr. Bruce E. Baker | 928 |
| Influence of Sulphate-reducing Bacteria on the Corrosion Potential of Iron.—J. N. Wanklyn and C. J. P. Spruit | 928 |
| A Quantitative Fluorescence Test for the Determination of Corticosteroids.—Dr. Michael Finkelstein | 929 |
| Observations on the Rate of Incorporation of Phosphorus-32 into Adenosine Triphosphate in Skeletal Muscle.—Prof. A. H. Ennor and H. Rosenberg | 930 |
| Differentiation of the Polygalacturonases of *Aspergillus niger*.—Dr. E. Schubert | 931 |
| Critical Evidence for Somatic Doubling of Chromosomes in a Top Yeast.—Miss Saraswathy Royan and Dr. M. K. Subramaniam | 932 |
| Lyophilic Properties of Isolated Serum-Protein Fractions.—Dr. Ch. Wunderly | 932 |
| Inhibition of Development of *Trichostrongylus retortaeformis*.—J. F. Michel | 933 |
| Occurrence of *Pelagia* in the River Yealm Estuary, South Devon.—O. D. Hunt | 934 |
| Effect of Acetic Acid on the Oxidation of Ascorbic Acid in Fruits and Vegetables.—F. Alm | 934 |
| Transitions in the Chromium–Manganese and Nickel–Vanadium Sigma Phases.—W. B. Pearson | 934 |
| Recent Scientific and Technical Books | Supp. vi |



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## NATIONAL PARKS IN BRITAIN AND THEIR CONTROL

THE North Wales Hydro-Electric Power Bill, which received a second reading in the House of Commons on April 1, has an importance which extends far beyond the areas affected either by the actual projects which the Bill is intended to sanction or by the power supply ultimately derived from these schemes. Upon the terms of the Bill and the nature of the safeguards written into it by the committee to which the Bill has now been committed may well depend the future and the reality of 'national parks' in Britain. Mr. H. Macmillan's refusal, as Minister of Housing and Local Government, to redeem his predecessor's broken faith, and honour the unequivocal assurance given by Lord Silkin, who was Minister of Town and Country Planning at the committee stage of the National Parks Bill, regarding the independent planning officers for any joint planning board, and the limitation of local authorities' representatives to two-thirds of the entire membership of the board, bids fair to give us 'local authority' parks instead of 'national' parks.

What is really at stake in the North Wales Hydro-electric Power Bill is whether the National Parks Commission and the planning boards for any particular park are to possess effective powers in the face of threats from government departments or public corporations which have been recognized, from the Dower Report onwards, as by far the most serious danger to the preservation of amenity in either Nature reserve or national park. There have been repeated demonstrations of the ineffectiveness of local authorities in the face of threats from such quarters. The proceedings in Parliament will now demonstrate whether or not there exists in either House sufficient concern for the preservation of Britain's scenic heritage, its flora and fauna to enforce those safeguards against departments judging their own cause which the present Government, like its predecessor, has hitherto been unwilling to prescribe.

The present Bill does not, it is true, cover all the eight schemes originally announced by the British Electricity Authority, and against which a reasoned statement was presented two years ago by the North Wales (Hydro-Electricity) Protection Committee. The Festiniog scheme was included, but the Authority has now announced that further action in this scheme is to be deferred. Modified versions of the original proposals for extensions to the existing Dolgarrog and Maentwrog schemes are presented. The Authority's intentions with regard to the remaining projects have not yet been indicated; but it is understood that Rheidol is the most likely, and Snowdon the least unlikely, to come next on the list.

In the Dolgarrog scheme it is proposed to double the catchment area of the low-level Coedty reservoir by a new cut which would intercept the Afon Dulyn and the head waters of the Afon Roe, and, with extensions to the existing power station, would increase the average annual output from 42 to 55·5 million units. The Maentwrog extension proposes,

by intercepting streams that now flow unused into the Vale of Festiniog, and all the tributaries entering the Eden from the west as far as Afon Scrw, to raise the annual output of the existing generating equipment from 30 million to 52 million units. The complex Festiniog scheme involves the establishment by stages of three power stations: one in the slag-heap wastes west of Blaenau Festiniog; one on the outskirts of the village of Tan y Grisiau; and a third on the banks of the Dwyryd, about a mile and a half above Maentwrog, in a conspicuous position in a much frequented valley of great beauty. The three stations together would have an annual output of 49 million units, and in supporting the second reading of the Bill, Mr. Raymond Gower put the new generating capacity as in the region of 45,500 kilowatts, the average cost per kilowatt installed as £94 5*s*. and the capital cost at about £4½ millions compared with £30 millions for all the original schemes.

Technically there has been discussion as to the economic merits of the scheme, on the grounds of the saving of coal, estimated as in the region of 55,000 tons per annum, particularly in comparison with Connah's Quay power station at present under construction, which was cited by Sir Patrick Abercrombie in his report to the County Council of Caernarvon on the hydroelectric schemes as providing the answer to rural electrification in North Wales. By running the Connah's Quay station at a load factor of 80 instead of the proposed 41 per cent by arrangement with the Merseyside power-producing units, Sir Patrick estimated the station could provide an additional 600 million kWh., or more than the 500 million that would be lost if the North Wales hydroelectric schemes were abandoned. Some of these highly technical issues, particularly on costs, appear to be still in dispute, but there is a further element of weakness in the schemes covered by the present Bill.

Even if the interference with scenic beauty is diminished by incurring the substantial cost of burying most of the cables, putting the pressure pipe-lines underground and excavating the power station and sub-power station back into the hillside, the adequacy of the water supply is uncertain. Although in the Festiniog catchment area the annual rainfall averages 97 inches, it is intermittent, and not all of it is available even if the Authority could hope to catch all the flood water. The available rainfall is estimated at 63 in., and of this the British Electricity Authority proposes to use 58·9 in., leaving between four and five inches as compensation water, averaged through the year. In dry seasons this clearly will be negligible, and agricultural and fishing interests, sanitary authorities and tourist interests are naturally concerned as to the adequacy of this amount, particularly in those dry periods when the farmers already have difficulty in watering their cattle.

These technical points were discussed in the House of Commons on April 1, and will no doubt be examined more fully in the committee stage of the Bill. Even on the second reading, however, they were not allowed to obscure the much more important and fundamental issues raised in relation to the national park, both the Snowdon Park in particular and national parks in general. As it stands, the Bill exempts from planning control roads, bridges, railways, electric lines, aqueducts, embankments, and other items, and gives the British Electricity Authority uncontrolled power to deepen, dredge, widen and alter lakes, streams and water-courses. The most serious objection to the Bill is precisely that it would authorize works which are bound to affect natural amenities in or near a national park, and at the same time the Bill deprives the planning authorities of any control over the way in which such works are carried out.

It is this point which invalidates any comparison with the Galloway scheme or some at least of the North of Scotland schemes, nor is it met by the important concessions already made by the British Electricity Authority, to which Mr. P. J. Noel-Baker referred in the course of the debate. Mr. Noel-Baker maintained that something more is at stake than any immediate economic advantage to be gained from the schemes. The lovely mountain country in question is sacred to the people of Wales and is a priceless possession for the people of Britain as a whole: nothing should be done now or later to imperil or destroy that heritage.

This, in other words, is exactly the principle upon which the whole conception of national parks and Nature reserves rests: Great Britain is small enough, and there are certain areas where scenic and scientific interests must stand supreme. Mr. Noel-Baker himself favoured the second reading of the Bill, subject to an instruction to the committee on the Bill to restore planning powers to the planning authorities. He did not consider that the three schemes proposed in the Bill were open to serious objection and stated that the National Parks Commission concurred in this view. Nor did he regard the Bill as creating a precedent for any of the other rejected schemes.

It is nevertheless difficult to reconcile this attitude with that of engineers who have submitted proposals for intruding on a 'national park area' which no responsible engineer would have suggested formulating in respect of a 'green belt'. This fact alone would account for the general fear that the Bill may constitute a precedent for further and disastrous inroads, and such fears were not removed by the assurance which was given later in the debate by the present Minister of Fuel and Power, Mr. Geoffrey Lloyd. Mr. Lloyd agreed that the amenity questions are the important and practical ones; but his statement that the British Electricity Authority, as a result of discussion with the Minister of Housing and Local Government, as well as with the Minister of Fuel and Power, now wishes to put back into the Bill the ordinary planning clause, and that the Ministers thought that it should also be obligatory on the British Electricity Authority to consult the Royal Fine Art Commission and the National Parks Commission about building and other works and to employ a landscape consultant whose advice should also be available to the National Parks Commission, led to the withdrawal of the instruction to which Mr. Noel-Baker had referred.

The second reading of the Bill was accordingly agreed in view of Mr. Lloyd's assurances that the amenity objections would be fully met in committee, and if any dispute arose over the treatment of spoil from the excavations or of the treatment of the banks of leats, walls, etc., proper provision would be made for reference to the Ministers for decision. Assurance was also given in regard to the question of water; but none of the assurances really met the crucial point as to why responsible engineers, on whose expert advice the Minister rightly relies in regard to technical details, have in the first instance and not just as a last resort put forward schemes which so seriously endanger a national park area. This is the real reason for anxiety, and it is increased by the lack of concern which the Parliamentary Secretary to the Ministry of Housing and Local Government, Mr. E. Marples, displayed in dealing with the question of joint planning boards in the adjournment debate on national parks on December 6. The British Electricity Authority may now well be concerned not so much to secure over-riding powers as to minimize the number of bodies with which it has to deal, and for its own part might be satisfied that the resistance of the county councils concerned has now led to the establishment of a joint board for the Snowdonia National Park, the planning officer of which could conveniently look after the Festiniog area, which is excluded from the Park area, in the same way as the planning officer for the Peak District Park looks after the Buxton enclave. This recent concession to local pressure was made, it should be noted, in spite of Mr. Macmillan's conviction that "the National Parks Commission are right in believing that a national park ought to be administered by one authority".

This, however, is only a sectional and particular settlement of a general issue. Other interests, besides electric power schemes, threaten the national park areas, notably the insatiable and unco-ordinated demands for training areas put forward by the Armed Forces, and the claims for mineral workings. One such, in particular, that for limestone, has a vital bearing on the existence of a national park in Derbyshire. To accept Mr. Marples's apparent assumption that the planning boards need not appoint an independent planning officer, and that their membership and operations should be a matter of indifference to Parliament, could be as fatal as acceptance of the assumption of the Limestone Federation that new quarries will be opened in the Peak district to maintain the same proportion of a rapidly increasing national output as it yielded before the district became a national park.

If a national park policy is to make sense, there must be areas where the interest of amenity and its enjoyment must stand supreme, even over economic and defence considerations, save in exceptional cases. The Minister has to determine the principles upon which the task of striking the right balance between incompatible uses of the same limited areas should be approached, and the earlier this is done the easier it will be to save both Parliamentary and ministerial time by enabling, and requiring, the public authority, or industry or defence ministry, to establish and prove the exceptional circumstances in respect of any and each particular claim. It is true that it will still be necessary to provide the National Parks Commission and the planning boards for the individual parks with a status which will ensure that their rejection of frivolous demands cannot be over-ridden at will by an interested party. The debate on the North Wales Hydro-Electric Power Bill nevertheless warrants the hope that Mr. Macmillan may honour the pledge so specifically given to Parliament that the planning boards set up for the national parks should be truly representative of the national interest, and provided with the financial resources and the staff required to enable them to pursue a national policy and not one dictated purely by local resources or interests.

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# CHEMICAL ACTIVITIES OF THE PROTOZOA

**Biochemistry and Physiology of Protozoa**
Edited by André Lwoff. Vol. .1. Pp. x+434. (New York: Academic Press, Inc., 1951.) 8.80 dollars.

WHILE our knowledge of the biochemistry and physiology of the Protophyta—especially bacteria and microfungi—has made considerable progress, relatively little is known about the chemical activities and functions of the Protozoa. Moreover, since the literature on these subjects is scattered in numerous periodicals, it has hitherto been difficult to obtain a comprehensive picture of the available data and to follow the advances made in the field of biological chemistry, nutrition, metabolism and growth requirements of the Protozoa. The study of these activities is both of theoretical and practical importance. On one hand, it furnishes material for a comparison of the Protozoa with other living organisms, and serves to emphasize the fundamental similarity of their essential metabolites and enzyme reactions; on the other hand, by giving an insight into the biochemistry and physiology of parasitic forms, it provides a basis for the understanding of the effect of pathogenic Protozoa on their hosts and for a rational approach to the chemotherapy of the diseases caused by them.

The book under review is the first volume of a symposium dealing with various groups of Protozoa. Each chapter is written by a recognized authority in the subject dealt with, while the editorship is in the hands of Dr. André Lwoff, whose wide knowledge of all aspects of protozoology fully qualifies him for this task.

In an introductory chapter, Dr. Lwoff defines the Protozoa and the place which they occupy among other protists, and gives an outline of their nutrition and physiological evolution. He develops the idea that the evolution of Protozoa has proceeded through a gradual loss of their ability to synthesize the organic sources of energy to the development of a mechanism which has enabled them to utilize particulate or dissolved organic food from their environment. S. H. Hutner and L. Provasoli deal with the Phytoflagellates. In discussing their phylogeny, they consider the concept of 'plant' and 'animal',

and the definition of 'Protozoa'. In the absence of clear-cut criteria, they propose to include in this group all permanently colourless forms and all nucleated phagotrophic protists. Since the physiology of the Phytoflagellates depends on photosynthesis, the evolution of the photochemical process in these organisms is described. In this connexion an account is given of the pigments and their bearing on the systematics of these flagellates. The authors also describe the metabolism of so-called 'acetate flagellates' (Lwoff's 'oxytrophs'), which flourish in media rich in acetate. They then turn to the loss of chloroplasts induced in some Phytoflagellates by the action of streptomycin, to the conditions under which photosynthetic flagellates grow in darkness, and to their utilization of nitrate. They further discuss the growth-factors and inorganic nutrition in various Phytoflagellates, and, finally, sexuality in *Chlamydomonas*.

An account of the nutrition of Protomonadine flagellates is given by Marguerite Lwoff, who has chosen the Trypanosomidæ and the Trichomonadidæ as material for the study of the growth-factors of blood and intestinal flagellates when cultivated in artificial media. T. von Brand reviews the important work of his school on the physiology of the trypanosomes. After describing their respiration and carbohydrate, fat and protein metabolism, he considers the nature of the pathological effect of these parasites upon their host, the physiological basis of chemotherapy of trypanosomiasis, and the mechanism of drug resistance. In a second chapter by Mme. Lwoff, a brief account is given of some aspects of the nutrition of the dysentery amœba, *Entamœba histolytica*, and attention is directed to roles which the oxidation–reduction potential of the medium and the presence of cholesterol take in its growth in culture. In a chapter on the malaria parasites, R. W. McKee first describes their life-cycle, metabolism and methods of cultivation, as well as their nutritional requirements *in vitro* and *in vivo*; he then discusses the *modus operandi* of anti-malarial drugs, giving special consideration to their effect on the metabolism of *Plasmodium*. The last chapter, by J. W. Kidder and V. C. Dewey, deals with the biochemistry of ciliates, based chiefly on observations on *Tetrahymena geleii* in artificial cultures: an account is given of their requirements in inorganic salts, respiration, and growth-factors. It is pointed out that, in view of their response to chemotherapeutic compounds, these ciliates can also be used for drug-tests.

Each section is accompanied by a list of references, and at the end of the book there are author and subject indexes.

There can be no doubt that this book will be of great value to a variety of workers—protozoologists, physiologists, biochemists and chemotherapists—who will look forward to the appearance of the second volume of this symposium. Useful as this book may be, it suffers from some of the defects of symposia in general, such as lack of balance between the different sections, some overlap in the questions dealt with in them, and the absence of a planned arrangement of the material, both as regards the systematic order of the organisms and the treatment of their chemical activities. These drawbacks are, of course, inevitable in a collective work of this type, but—*faute de mieux*—it is the best that could be done in the present fragmentary state of knowledge of the biochemistry and physiology of the Protozoa. C. A. Hoare

## SOUTH AFRICAN PLANTS

### The Genera of South African Flowering Plants

By Dr. E. Percy Phillips. (Union of South Africa: Department of Agriculture, Division of Botany and Plant Pathology: Botanical Survey Memoir No. 25.) Second edition. Pp. xi+923. (Pretoria: Government Printer, 1951.) 40*s*.

THE flora of South Africa has claimed the attention of taxonomists and phytogeographers from the earliest days of exploration and colonization of the Cape of Good Hope. All have remarked on its amazing variety, complexity and wealth of species, the high proportion of endemics and the virtual botanical isolation of the south-western region from the remainder of the African continent. Dr. E. Percy Phillips's new book does not stress these points; it is a straightforward account of the genera of plants found within the boundaries of the Union and will provide statisticians, plant geographers and taxonomists with material for argument and discussion for many years to come.

The first edition of the work appeared a quarter of a century ago, and was a simple compilation; the new book has been produced on the same lines, but the descriptions of the genera have been amended and extended as a result of Dr. Phillips's personal observations and dissections of material representing some thousands of species.

It is an intensely practical handbook, intended primarily for the use of ecologists, foresters, veterinarians, land-utilization officers and others to whom identification of plants is of importance. For such purpose it is admirably conceived.

The dichotomous key to the families is a continuous one; there is no subdivision into groups such as were adopted by Dr. J. Hutchinson in his "Families of Flowering Plants". This makes the key somewhat cumbersome—it occupies forty-five pages—but on test against family and generic descriptions it works well; I found no 'errors' in twenty such tests. In order to avoid difficulties introduced by 'anomalous' genera and by monœcism and diœcism, some families are included several times. Each family of more than one genus is similarly provided with a key. The characters used are nearly always such as can be observed in the field by the aid of a simple hand-lens.

The arrangement of the families and genera follows exactly that of Dalla Torre and Harms, even to the numbering of the genera, with the inevitable gaps for genera which do not occur in the Union and the addition of *a*, *b*, *c*, etc., for genera described since the publication of Dalla Torre and Harms. The somewhat inadequate reason given for the adoption of this arrangement is that the National Herbarium, Pretoria, is arranged by it. Taxonomists will complain that Dr. Phillips might have chosen this opportunity to give them some of his own conclusions on the limits and affinities of the families and genera based on his lifetime's enthusiastic work on the South African flora. In many instances where more recent opinion differs from that of Dalla Torre and Harms, non-committal notes only are given.

The result of Dr. Phillips's choice of arrangement has led to the apparent rejection of the family Welwitschiaceæ as distinct from Gnetaceæ; of Hutchinson's now generally accepted transfer of the onion tribe to the Amaryllidaceæ; to the inclusion

of the Hypoxidaceæ in the Amaryllidaceæ, *Hypericum* in the Guttiferæ, and *Lobelia* and its allies in the Campanulaceæ; *Retzia*, now usually regarded as a monotypic family, is included in the Solanaceæ; Selaginaceæ are not separated from Scrophulariaceæ; and *Roridula* is not separated from Droseraceæ, though there is now general agreement on its family status near the Pittosporaceæ. This last family retains a very old circumscription; most of the genera here included are now removed to the family Molluginaceæ (Hutchinson) or to the Aizoaceæ [Ficoidaceæ] (Pax and Hoffmann). Orchidologists will be surprised at the treatment of the Angræcoid orchids; *Listrostachys*, credited with eighty-six species, is more usually regarded as monotypic and confined to West Africa (except for a doubtful record from Réunion). The South African representative is the type species of the genus *Cyrtorchis*.

The nomenclature adopted follows, so far as possible, the latest edition of the International Rules; a useful addition, as compared with the first edition, is the citation of the original place of publication of the accepted generic names. Dr. Phillips has also made a notable contribution towards nomenclatural stability by citing the type species (either holotype or lectotype) for most of the genera. This represents a prodigious bibliographical research as well as a great ability to judge the value of various authors' taxonomic opinion. It may be well to direct attention to one error in this section: on p. 133 *Triraphis pungens* is cited as the type species of the genus, whereas it is, in fact, now regarded as a species of the Australian genus *Plectrachne* Henrard. The type of *Triraphis* as amended by Stapf in the "Flora Capensis" is *T. mollis* R.Br. A further noticeable error occurs on p. 136, where *Leptocarydion* is cited as "Hochst. ex Benth. et Hook. f.", although in a footnote Dr. Phillips makes it clear that this should be "Hochst. ex Stapf", since Bentham and Hooker regarded it as a synonym of *Triodia*.

Horticulturists will be disappointed in the treatment of *Mesembryanthemum* sens. lat., often now regarded as a distinct family. It is of interest to note that Dr. Phillips, following the late Dr. N. E. Brown, cites *Mesembryanthemum umbellatum* as the type of the genus in the restricted sense, instead of either of the lectotypes severally proposed by Dr. Schwantes and Dr. L. Bolus. The key includes only sixty-four of the segregate genera which have been proposed since the late Dr. N. E. Brown commenced his unfinished monograph in the early 1920's, the remaining seventy or eighty being relegated to a mere list.

In all, nearly eighteen hundred genera are described, distributed very unevenly in a hundred and eighty families, as shown in the accompanying table.

It is clear that, had Dr. Phillips adopted more modern conceptions of family limits, the number of monotypic families would be materially increased, while other totals would remain substantially the same. Gramineæ, with 161 genera, and Compositæ, with 194 genera, are the largest families.

| | No. of genera | No. of families | Families with number of genera | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 1–20 | 21–50 | 51–99 | 100 or more |
| Gymnosperms | 5 | 4 | 3 | 1 | 4 | 0 | 0 | 0 |
| Monocotyledons | 428 | 30 | 11 | 4 | 24 | 4 | 1 | 1 |
| Dicotyledons | 1359 | 146 | 49 | 16 | 134 | 7 | 2 | 3 |
| Totals | 1792 | 180 | 63 | 21 | 162 | 11 | 3 | 4 |

A number of genera represented only by introduced or naturalized species are included; it might have been better to use smaller type in the text and keys for these plants. The Cactaceæ, represented by *Rhipsalis cassytha*, are included as native; but it is at least doubtful whether any member of the Cactaceæ is truly native in the Old World. *Rhipsalis cassytha* is now very widely distributed throughout the tropics and subtropics, but one cannot readily dispose of the idea that, in the days of sailing ships, it was carried all over the warmer regions as a substitute for mistletoe.

The book concludes with a very useful, but by no means exhaustive, bibliography. Covering forty-nine pages, it is arranged alphabetically under genera and families, with interpolations under such headings as "Nomenclature" and "Phylogeny". The latter is remarkable for the omission of a reference to Hutchinson's "Botanist in Southern Africa", in which a long chapter is devoted to that author's conclusions on the subject as exemplified by the South African flora.

The final index of generic and family names is referred back to the main entry in the text by means of the Dalla Torre and Harms numbers; the page number is added for the family names. Throughout, printers' and proof-reading errors are few; transposition of letters gives, for example, "*Fescuta*" for *Festuca* in the key to the Gramineæ on p. 76, while the abbreviation of "Lagasca" to "L." as the author of the name *Perdicium*—a synonym of *Gerbera* Cass.—will invariably be read as Linné, although Dr. Phillips normally abbreviates that author's name to "Linn.". Such errors are, however, inseparable from a work of this size, and in no way detract from its very real merit as a contribution to our knowledge of South African plants. At £2 it is the best book value of its kind which has appeared for some time, and should find a place on the shelves of all comprehensive botanical libraries. Its usefulness extends far beyond the political boundaries of the Union, and it will be a very welcome addition to the equipment of field-workers in Mozambique, Nyasaland, the Rhodesias and throughout East Africa.

A. A. BULLOCK

## AN AMERICAN VIEW ON CIVIL DEFENCE

### Civil Defense in Modern War

A Text on the Protection of the Civil Population against A B C Warfare (Atomic, Bacterial, Chemical). By Brigadier-General Augustin M. Prentiss. Pp. xv+429. (London: McGraw-Hill Publishing Co., Ltd., 1951.) 51*s*.

IN his study of the problem of civil defence, the author makes it clear that the views expressed are personal and not necessarily in agreement on all points with official policy in the United States. In this very fact, perhaps, lies much of the interest and merit of the work. Many books have been written on individual types of modern warfare and on specific aspects of their bearing on civil defence, but there must be few, if any, which present such a comprehensive and objective study of the whole problem.

The treatment is systematic and consists of three parts, dealing respectively

with modern methods of air warfare, the possible methods of protection against each of these and finally with the formulation of a tentative scheme for a practical civil-defence organization. The fifteen chapters, comprising Parts 1 and 2, are a masterpiece of condensation. A realistic picture of chemical, 'bacterial' and atomic warfare is presented, avoiding the alarmist sensationalism that has been all too common in some publications in recent years, and yet in no way under-estimating the potentialities of these methods of attack if timely preparation of appropriate counter-measures is neglected. The subject is studied from the point of view of a military scientist, and a short interesting chapter on "Choice of Military Agents" summarizes the arguments likely to influence an enemy in his selection of weapons for an attack on a civilian population in given circumstances.

In a work so packed with factual information, and in which the arguments are so logically presented, a serious critical review within the limited space available is scarcely possible, and the selection of isolated points for detailed criticism would be ill-judged and misleading since, in my opinion, the special merit of the book lies in the method of approach to, and treatment of, the subject as a unified whole. Readers familiar with the trend of thought in Great Britain will doubtless find points where they disagree with the author's conclusions; but it should be remembered that, in a vast country like the United States with its numerous but widely spaced cities and large areas of thinly populated land, some of the problems of civil defence must inevitably differ from those facing a compact and densely populated island like Great Britain. This fact may well account for some of the differences in the relative values attached to alternative methods of defence against specific hazards as compared with those generally accepted in Great Britain.

There is, of course, nothing new in the technical data, but the information is well and concisely presented, and the reader will find much of interest in the author's exposition of his views on how this important problem should be approached and how an effective scheme of defence might be developed. The book is excellently produced on high-quality paper, is illustrated with charts, diagrams and photographs, and contains an extensive bibliography and useful index.

J. W. Martin

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## THE RHYTHM OF REPRODUCTION

### Vertebrate Sexual Cycles

By Dr. W. S. Bullough. (Methuen's Monographs on Biological Subjects.) Pp. viii+118. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1951.) 6*s*. net.

THE hundred pages of this well-arranged and useful little book provide a general picture of the rhythm of reproduction in vertebrates. The opening chapter deals with the age at which different creatures become sexually mature; with the timing of the mating season; with the effects of natural selection on breeding habits; with possible changes in reproductive habits caused by domestication; and finally with the œstrous cycle, starting with fish and amphibians.

In the chapter which follows, Dr. W. S. Bullough proceeds to consider the influence of environmental factors on the physiological mechanisms which underlie the annual breeding season. He refers to the reproductive behaviour of seasonal breeders that have been moved across the equator, and briefly discusses the influence of light on reproductive periodicity. Other possible external factors which in some species may initiate the breeding season—for example, rainfall and temperature—are also mentioned.

The next of Dr. Bullough's chapters deals with the hormonal control of reproductive processes. Here, for the first time, the review becomes coloured with some of Dr. Bullough's own beliefs: in particular, the view that the androgenic and œstrogenic hormones can be regarded as 'mitogenic' hormones that stimulate cellular proliferation not only in the reproductive organs but in the body as a whole; and the idea that the gonadal hormones themselves stimulate gametogenesis—especially the idea that, when a follicle ruptures at the appointed time in the œstrous cycle, follicular fluid bathes the surface of the ovary and stimulates the germinal epithelium to form a new crop of oogonia.

Dr. Bullough then moves on to consider the hormonal control of the accessory reproductive organs, and the possible links between receptor organs such as the eye, which are apparently involved in the control of reproductive periodicity by light, and the pituitary. The final chapter deals with sexual behaviour and its hormonal control.

A book of this kind inevitably has defects, for brevity is the most exacting of task-masters where accuracy of statement is being sought in a field of knowledge the boundaries of which shift almost daily. In the paragraph with which he concludes his chapter on hormones and reproduction, Dr. Bullough warns his reader—and reviewer—that another worker might well have emphasized different features of the story, and possibly drawn different conclusions. But he opens the section in which this particular remark appears with the statement that the conclusions which he proposes to underline are non-controversial ones. That, unfortunately, they are not. Among the few which he includes in the category of presumably established generalizations are the statement that the gonadal hormones are gametogenic—a thesis which the facts more readily dispose of than sustain—and the view that the gonadal hormones are general, as opposed to specific, stimulants of mitosis—a view for which the evidence is both scanty and contradictory. The book also contains some statements which appear to be incorrect, apparently because of misplaced emphasis—for example, the suggestion that platyrrhine monkeys have typical œstrous cycles of the kind seen in non-primate mammals, as opposed to the menstrual cycle of the Old World primates; the implication that the ovulation which is induced in the rabbit by mating does not occur until about twenty-four hours after the stimulus is applied; and the suggestion that there has been no detailed study of the human menstrual cycle. There are also a few sins of omission—for example, the book contains no reference at all to the occurrence of pseudopregnancy.

Happily, these shortcomings do not obscure the positive merits of the monograph; and Dr. Bullough could always correctly claim that he did go to the trouble of cautioning his readers that final answers belong to the future, and that, in the nature of things, they might not necessarily coincide with any contemporary views.

S. Zuckerman

# THE UNIVERSITY OF SOUTHAMPTON

By Prof. N. K. ADAM, F.R.S.

THE grant of a Charter to the University of Southampton has given very great satisfaction to the Council, staff and many friends of the Hartley University College, who have worked long and hard to lay the foundations of a University in mid-southern England. The new University had its origin just over a century ago, when Henry Robinson Hartley, a wine merchant of Southampton, left about £100,000 to found an institution with a library, museum, and botanic garden, in which natural history, antiquities, classical and oriental literature, etc., could be studied. Unfortunately, the founder's will was far from making his intentions clear, and prolonged litigation reduced the value of the bequest to about £40,000. Out of this the Hartley Institution, opened in 1862, was built and equipped; it contained a large and imposing hall often used for major public occasions, a museum, and some class rooms, the latter forming the nucleus of a teaching institution. Day and evening students attended the Institution; but for some decades the number of full-time students was small. Prof. Hewitt records that, in 1881, he entered the Institution at the age of thirteen, being the youngest of about twenty students, in science and literary subjects; these included F. W. Lanchester, the pioneer of motor-car and aeroplane design. Chemistry was then taught by the principal, T. W. Shore, and the borough analyst. There was also an art school.

Towards the close of the century, serious attempts were made to develop teaching of university standard; in 1893, Mr. William Garton left money to build an engineering laboratory, staff of university calibre were recruited as the very meagre funds permitted, and in 1902 the Institution was incorporated as the Hartley University College. From that time the growth of the College was steady, if slow; the abler students took degrees of the University of London, there was a steady output of trained teachers, and the College also acted as the technical college for Southampton, with some hundreds of part-time students.

The original site in the High Street was clearly inadequate for a university institution, and by 1914 the College had acquired land in Highfield, and erected a substantial building. This was taken over by the War Office as a hospital, and the move to the new site was not made until 1919. With the rush of post-war students, problems of accommodation were severe, and much use was made of the wooden huts which had formed most of the hospital; a few of these are still in use.

The principalship of Mr. Kenneth Vickers, from 1922 until 1946, was the period during which the foundations of university status were solidly laid. Numbers of students fluctuated, but did not show any steady increase between the two World Wars. The University owes an incalculable debt to Mr. Vickers and a small band of devoted staff, who cheerfully gave almost their whole working lives, with small salaries and a load of undergraduate teaching far greater, and facilities far less, than the normal for university work. Two of these may perhaps be mentioned. Prof. D. R. Boyd, who in 1896 was appointed lecturer in chemistry with some teaching duties in elementary physics, and was vice-principal and dean of the Faculty of Science for many years, maintained a very high standard of teaching until his retirement in 1937. With his research students, he made substantial contributions to organic chemistry. Some of his pupils are well-known chemists, among them Prof. C. K. Ingold, now president of the Chemical Society. Prof. J. Eustice, appointed "Geometrical and Engineering Teacher" in 1895, founded and inspired a School of Engineering which grew steadily until his retirement in 1931. Past students still speak with great affection of these and others among their teachers. Between the Wars, the College had on its staff several young men who have since risen to high academic positions elsewhere.

During the past thirty years, continuous progress has been made in acquiring land and erecting permanent buildings, both for academic and residential purposes. In 1927, botanical laboratories were provided out of a bequest by Mr. George Moore; in 1929, Highfield Hall, for women, built on the site of a house previously used for the same purpose, was given anonymously; in 1931 Connaught Hall for men was opened; the permanent engineering workshops were begun in 1932, and have since been extended. In 1935, a fine library was provided out of a bequest by Mr. Edward Turner Sims. 1938 saw the opening of the physics laboratory; in 1940 the refectory and students' union was completed and a block of lecture rooms for the Department of Engineering built.

Under the energetic administration of Sir Robert Wood, principal since 1946 and now the first vice-chancellor, building has been accelerated; and despite post-war difficulties, nearly all the new buildings are permanent and designed to harmonize with the rest of the University. A large site at Glen Eyre, half a mile from the University and large enough for several halls, was purchased in 1947; on this a hall for men has been built and occupied in stages. An assembly hall, which can also be used as a gymnasium and a theatre, and the Institute of Education, were built in 1949; the new zoological laboratories were opened in 1951 (a photograph of the new Zoological Museum appeared in *Nature* of December 29, 1951); part of a new chemistry building was finished in 1948 and a large further instalment is expected to be ready for next session. A disused brickfield, abutting on Southampton Common, now belongs to the University and provides generous space for future academic extensions; a small part of it is now being developed as a botanic garden for experimental plants.

The University will have six faculties: Arts, Economics, Education, Engineering, Science, and Law; the last will commence next session. There are professors of mechanical and aeronautical engineering; senior lecturers have charge of civil and electrical engineering. Besides the usual three-year undergraduate courses, it is intended to operate a 'sandwich' scheme, under which young engineers will spend alternate periods in whole-time study and working in industry, eight terms in four years being spent at the University. This scheme is being well supported by local firms, especially in the aircraft

University of Southampton: Main Building and Library

industry. In science, there are professors of botany, chemistry, electronics, pure mathematics, applied mathematics, physics, and zoology; geography and geology are in charge of a senior lecturer and a lecturer. Electronics is a postgraduate subject, for which the University confers a diploma.

The number of students has grown very rapidly since the War. In 1939, there were fewer than three hundred University students; there are now 980, including 350 in the Faculty of Science and 130 in the Faculty of Engineering. About half the students live in University halls; in addition to the three modern halls, two large houses—one very large—have been converted into students' residences. As further building at Glen Eyre becomes possible, it is intended to provide further halls, so that all students can spend some of their time in residence in hall, and as many as possible all their time.

The University will, probably for many years to come, continue to undertake the more advanced teaching usually done in technical colleges. There are about 1,300 'technical' students, a few whole-time taking courses in marine or radio engineering; and many part-time, mostly engineers, but including about 150 in various branches of science. Many of these are preparing for Higher National Certificates and various professional qualifications.

Research is active in all departments. In mathematics, differential geometry, the theory of numbers, and the theory of nuclear energy-levels are the principal topics. In engineering, the causes of noise from jets are being studied by photographing sound waves and eddies; work is also proceeding on trans-sonic wind tunnels, directional grain effects in light alloys, railway bogies, and web stiffening of plate girders. Among the researches in physics and electronics are micro-wave spectroscopy, the growth of single metallic crystals, acoustics of organ pipes, optical properties of metallic films, streaming double refraction and anomalous viscosity, and susceptibilities in intense magnetic fields. A team of chemists is studying the kinetics of halogen replacement in organic compounds, and work is in progress also on the synthesis of substances with anti-histaminic activity, stereochemistry, inorganic co-ordination compounds, and other topics. In co-operation with the British Launderers' Research Association, some aspects of detergent action have been studied recently; and work is commencing on heterogeneous reactions in which the rate of diffusion to a surface is a major controlling factor.

The famous fishing rivers, Itchen, Test, and Avon, and the numerous creeks and harbours of the Solent and Southampton Water, make the University an excellent centre for studying the biology of fresh and brackish waters; and the variety of soils and conditions in the district favours studies on the physiological aspects of ecology. At present special attention is being paid to copepods and the larvæ of midges, behaviour in the field being correlated with experimental studies in the laboratory. A beginning is being made with physiology, which at first will be an undergraduate subject up to general B.Sc. level; research is active on the relation of the pituitary gland to carbohydrate metabolism and colour change. In botany, the main lines are: physiology of stomata, metabolism of organic acids in plants, the effect of X-rays on chromosomes; and, with support from the Forestry Commission, plant diseases with special reference to larch canker.

Finally, lest we forget, the founder's name is perpetuated in the Hartley Society, to which past and present members of the University and the University College may belong.

# PRESTRESSED CONCRETE*

By O. J. MASTERMAN

Unit Construction Co., Ltd., London, S.W.1

PRESTRESSING is an important development of reinforced concrete engineering designed to counteract the weakness of concrete in tension. In reinforced concrete, steel rods are inserted to carry the tensile forces; but they do not prevent the concrete from cracking. This is wasteful and objectionable. Prestressing applies a compression to the structural member before it is loaded, designed to neutralize the tension caused by the working loads and so eliminate cracking. This permits considerable economies in design, and results in a new material having qualities superior to those of normal reinforced concrete.

In building, there has always been a need for a cheap, strong, durable material having equal strength in tension and compression, because most structural members experience some degree of bending, and when bending occurs tension and compression forces of equal amount are set up in the material.

It was the lack of tensile strength in the building materials of the ancients which so limited the forms and capabilities of their permanent structures and restricted them to massive arches and domes for spanning all but the shortest openings. It is true that timber was available from earliest times, and this wonderfully versatile material has nearly equal strength in tension and compression: it cannot, however, be regarded as a permanent material.

In recent times, therefore, the use of steel and of reinforced concrete has brought about a marked change in building design, because these two comparatively permanent materials can resist bending stresses economically and permit structural members to be of much more slender section. Wide spans present no difficulties, and tall columns need not be massive. There are, however, some drawbacks in both these new materials. Steel, for example, requires expensive protection against corrosion as well as fire, while reinforced concrete does not employ its two constituent materials to the best advantage because of the cracking which must occur in the tension zone of the loaded members.

This is due to the fact that, when the loads cause bending, the concrete surrounding the embedded steel cannot stretch to the same extent as the steel, and must crack before the steel has reached its working stress. It would be quite uneconomic to work the steel at such low stresses that this cracking is avoided: this would restrict the steel tensile stress to about 3 or 4 tons per sq. in. In fact, the necessity of limiting the cracks which do occur to a maximum width of about 1/100 in. to avoid corrosion trouble limits the acceptable maximum steel stress to a figure —about 8 or 9 tons per sq. in.—which is already low in comparison with stresses of 50 tons per sq. in. and upwards which are quite permissible for the high-tensile steels now available on the market.

But this cracking of reinforced concrete members subjected to tension causes further waste in that the designer is obliged to ignore all the concrete below the neutral axis: about six-tenths of the concrete depth from the tension face is considered as giving no help in resisting bending stresses. Thus a substantial portion of the concrete which must be provided and carried is very inadequately used.

The importance of the technique of prestressing lies in its ability to eliminate the tensions which cause the cracking, thus enabling the whole concrete section to be fully employed, and the steel which is used to effect the prestressing to be worked at whatever stress is safe for the quality selected: stresses of 50–70 tons per sq. in. are commonly adopted, the ultimate strength of the steel being about twice as much.

The underlying principle was used (though not understood) as early as 1886 when Doehring in Germany took out a patent and made some prestressed mortar slabs. Other workers were approaching the same idea during the next twenty years and several attempts at prestressing were made in that period; but the properties of concrete were not then well understood: the applied prestress was insufficient and after a short time disappeared owing to creep and shrinkage. Faber's researches published in 1927 and Glanville's in 1930 threw much light on the movement of concrete under stress and confirmed ideas on which Freyssinet had been working for some time in France. It was Freyssinet who first made clear the need for employing high-strength steel and concrete so that movements due to creep and shrinkage would have only a small effect in reducing the applied prestress. He was the first to build important works (from 1934) in prestressed concrete, and he is by common consent regarded as the originator of this valuable technique. His ideas were quickly taken up on the Continent by Hoyer in Germany and Magnel in Belgium, each of whom, like Freyssinet, devised his own particular method for obtaining the prestress. Recently in Britain the Lee–McCall method has been developed.

## Principles

The effect of prestressing is most simply seen by considering a beam of rectangular section as in Fig. 1*A*. When such a beam is loaded, compression stresses are induced in the top and tension stresses in the bottom: both are usually at maximum value near the middle. This section will, therefore, be considered in the following discussion.

If a compression $P$ is now applied axially at the ends of the beam as in Fig. 1*B* (considered for the moment to be weightless and unloaded), a uniform compression is produced throughout the beam which can be adjusted so that it just neutralizes the maximum tension stresses in Fig. 1*A*; but the compressive stresses in Fig. 1*A* would be increased. This would not be too serious, because concrete carries compression cheaply; it is, however, easily avoided by lowering the line of application of $P$ to a point one-third of the beam height from the bottom, as in Fig. 1*C*. In this position, a compression of double the amount in Fig. 1*B* is induced in the bottom face and the stress in the top face is reduced to zero. Stresses are indicated in the stress diagrams beside each figure. The amount that $P$ is moved from the central position is known as the eccentricity $e$.

It is now clear that if the conditions of Figs. 1*A* and 1*C* are superimposed and the stresses are added algebraically, the prestress $P$ has been arranged in the most effective way for eliminating the tensile stresses due to the loading. In practice, the magnitude of $P$ is adjusted so as to induce in the bottom fibres of the beam a stress equal to the maximum permissible working stress for concrete. This is generally

* Based on Special University Lectures delivered at King's College, University of London, on February 26 and March 4.

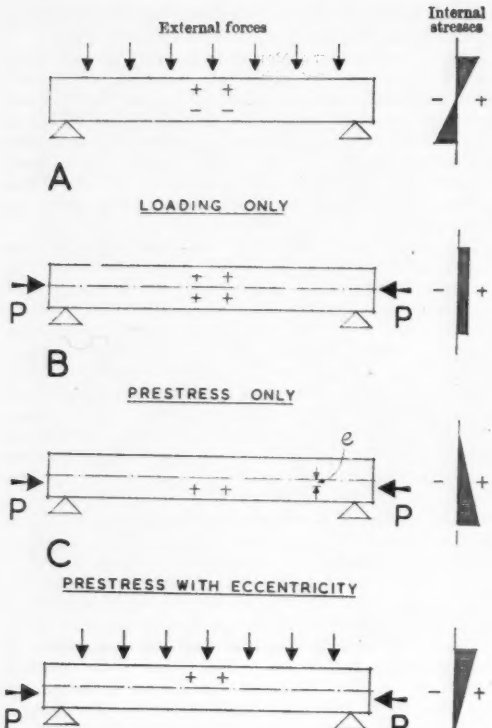



Fig. 1

taken as one-third of the cube crushing stress, and is usually about 2,000 lb. per sq. in., though higher figures implying cube strengths greater than 6,000 lb. per sq. in. are quite practicable and economic.

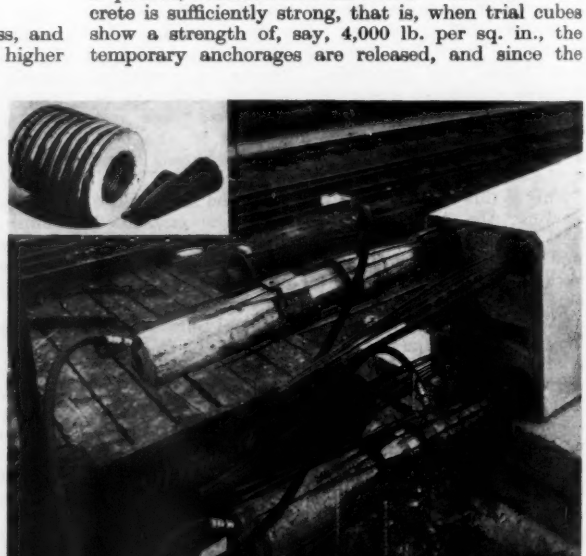
It will be seen from Fig. 1*D* that, when the pre-stress has been applied and the beam has been loaded, the maximum compression stress has moved from the bottom to the top fibres: the whole concrete section has been usefully employed, and at no time has any tension existed in the concrete. This elimination of tension is the essence of the technique.

One important feature may be noted at this stage: in the preceding argument, loading included all loads, both dead and live, taken together; they will now be considered separately. In Fig. 1*C* where no loads were acting, the line of action of *P* was lowered to a point at which compressive stresses at the top of the beam just disappeared. Any further lowering of *P* would have caused tensile stresses in the top fibres. If, however, the weight of the beam is acting when the prestress is being applied, it will neutralize such top tension up to the amount which its weight would produce. *P* may therefore be lowered correspondingly without causing tension to occur. This means that the dead-weight of the beam is being carried by merely increasing the eccentricity without any increase in the section of the beam or the pre-stress. This explains what is sometimes known as 'the beam carrying itself'; it clearly produces a valuable economy in cases where the dead-weight of the structure, as in a bridge girder, is high in relation to the loads carried. In large spans, however, the dead loads cannot be wholly carried by merely increasing the eccentricity, because this would bring the line of action of the prestress outside the beam, which is not usually practicable. It does, however, permit the centre of prestress to be lowered well below the 'one-third' point.

## Methods

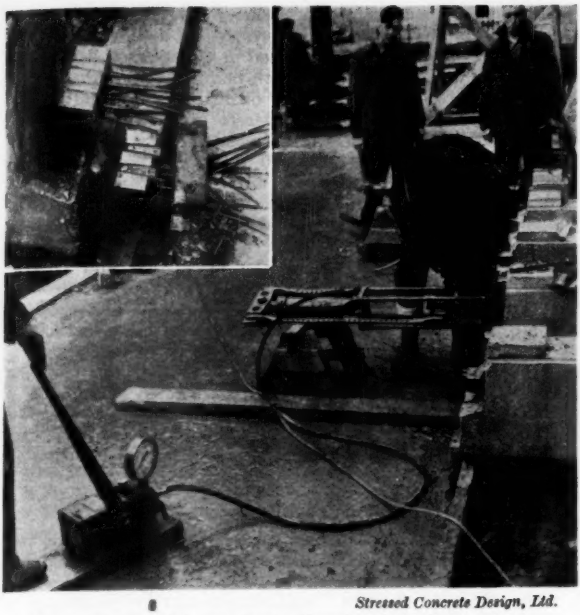
In practice, though steel is by no means essential, the prestressing of concrete is nearly always done through the agency of high-tensile steel wires or rods (known by Freyssinet as 'tendons') which are stretched to about two-thirds of their ultimate strength and then locked to the concrete. There are two ways of doing the locking: one is by bonding the concrete to the tendons along their whole length—this is known as the bonded method; the other is by mechanically locking the stretched tendons to each end of the member after the concrete has hardened. This is known as the end-anchored method.

In the bonded method, which is also called the long-line method, because any convenient number of units may be cast on a single line of stretched tendons, two fixed anchorages are set at any suitable distance apart: in production factories this is often several hundred feet. The tendons, arranged in the desired formation, are passed through drilled holes in the anchorages and then are temporarily anchored at one end, stretched the required amount and temporarily anchored at the other end. While in the stretched condition, moulds are set around them and concrete is poured, vibrated and hardened. When the concrete is sufficiently strong, that is, when trial cubes show a strength of, say, 4,000 lb. per sq. in., the temporary anchorages are released, and since the



*Pre-stressed Concrete Co., Ltd.*

Fig. 2. Freyssinet jacks in use. Inset: Freyssinet male and female anchorage cones



*Stressed Concrete Design, Ltd.*

Fig. 3. Magnel jack in use. Inset: Magnel sandwich plate anchorages

bond prevents any slip between the concrete and the steel, the pre-tension in the tendons sets up a corresponding pre-compression in the concrete: this latter is the prestress.

In the end-anchored method, which is also called post-tensioned because the stretching is not done until after the concrete has been cast and hardened, the tendons are wrapped with a suitable sheathing to prevent them bonding to the concrete; alternatively, holes are cast in the concrete and the tendons are threaded through them afterwards. In either case the concrete is first hardened sufficiently and then the tendons are anchored at one end of the concrete and then stretched and anchored at the other end, the concrete itself providing the reaction for the stretching force. In very long units, the stretching is done from both ends simultaneously. Grout is finally forced along and around the tendons to prevent corrosion.

The bonded method is generally used for the smaller factory-made components for which end anchorage would be too costly. Post-tensioning is almost invariably used for large work *in situ*.

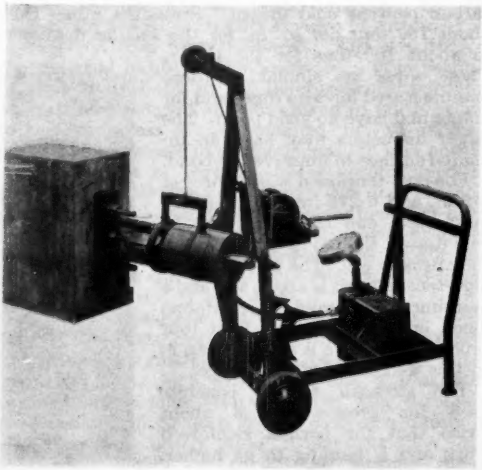
## Equipment

Whichever system is used, the stretching of the tendons is nearly always done by hydraulic jacks, which are readily available and are reasonably cheap and compact in relation to the forces they exert. The main difficulty is not in doing the stretching but in holding the tendons. The various grips and anchors that have been devised for this purpose constitute the characteristic features of the different systems. The Freyssinet anchorage is a conical concrete plug driven into a reinforced concrete cylinder having a conical hole; 12-wire cables are usual and the plug is fluted to accommodate the wires around its periphery. The special double-acting jack is arranged with lugs around the barrel between which the wires are temporarily wedged in pairs. With the head of the jack pressed against the anchor cylinder, which is itself cast into the concrete member, one ram is operated to stretch the twelve wires the required amount, after which the second ram drives the plug forward and anchors them in the cylinder (see Fig. 2). The jack gives a 30-ton pull to the cable and a 20-ton push to the plug when 12-wire cables of 5 mm. diameter are used, but other sizes are available.

The system adopted by Magnel uses a smaller jack and tensions only two wires at a time, these being anchored in a slotted steel plate by driving a steel wedge between them (see Fig. 3). These 'sandwich' plates are built up in tiers at the end of the concrete member to form the anchorages of multi-wire cables. Wires of 5 mm. and 7 mm. diameter are commonly used, and are tensioned to about $2\frac{1}{4}$ and $4\frac{1}{2}$ tons each respectively. Thus in the Sclayn bridge in Belgium, a two-span continuous hollow slab 406 ft. long over the main spans, the thirty-six cables of 7-mm. diameter wires exert a total force of more than 5,500 tons.

The Lee–McCall system employs high-tensile rods for the tendons, and these are provided at their ends with a thread and nut to form the anchorage. The thread is specially designed to enable the full diameter of the rod to be effective. The jack has a coupler which screws on to the end of the rod to be stretched (see Fig. 4). This system is very simple to work, and the anchorage, which does not rely on friction, is positive. The chrome manganese steel bars are of 70 tons per sq. in. ultimate strength, and are tensioned to about 42 tons per sq. in.

These are all end-anchored systems: the Freyssinet cables have the wires enclosed in a thin steel sheath and are cast into the concrete in the required positions. The Magnel cables and the Lee–McCall rods are threaded into holes formed in the concrete by means of inflated rubber tubes. In these two latter systems, steel plates bedded in the ends of the stressed member distribute the prestress force from the anchorage into the concrete. The Freyssinet



*McCall's McAlloy, Ltd.*

Fig. 4. Lee–McCall jack and anchorage

anchorage cylinder performs the same duty. In all three systems, it is usual to grout-in the tendons after stressing, so as to prevent corrosion and obtain the added advantage of bond with the concrete.

In the bonded or long-line method, in which individual thin wires are used often in large numbers, all the wires in one line are tensioned simultaneously by jacking back the crosshead at one of the abutments. The method of holding them varies: sometimes each wire is separately anchored against the crosshead, sometimes they are held in pairs and sometimes the whole group is passed through a thick steel ring and anchored by driving a conical pin into the centre of the group inside the ring. These are only temporary anchorages to hold the stretched wires while the concrete hardens around them. The bond then formed between the concrete and the steel is considerably enhanced by the shrinkage of the concrete as it hardens and the swelling of the wires when the temporary anchorages are released.

A proportion of the applied prestress is lost due to creep and shrinkage of the concrete and creep of the steel and, in the case of the bonded method, due also to the elastic shortening of the concrete member itself when the pre-tension is released. This last loss does not occur in the end-anchored method because the tensioning is done against the member itself instead of against fixed abutments. These losses must be understood and allowed for by the designer, who increases the applied prestress to cover them, generally providing an extra 10–15 per cent in the end-anchored method and 15–20 per cent in the bonded method. Thus wires of 1/10 in. in diameter with an ultimate strength of 120 tons per sq. in. would be tensioned initially to about 84 tons and would finally be working at 70 tons, or a little more than half their breaking strength, after all the losses had taken place.

## Materials

It has been said that prestressing, by eliminating tension, frees the concrete designer to use his materials to better advantage. Steels five times the strength of mild steel are normally employed, and it is also beneficial to use concrete of higher strength than is usual for reinforced work.

Steel wire for bonded prestressing ranges in diameter from about 1/15 to 1/5 in. and is of high-carbon content cold drawn. Strengths range from about 150 tons per sq. in. for the smaller diameters to about 100 tons for the larger. These wires are similar to those manufactured for wire ropes and for pianos and have no yield point. The larger diameters may have an indented surface to improve the bond.

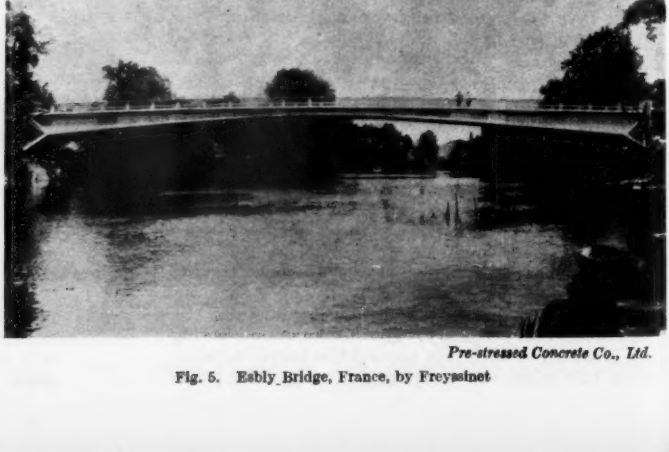
For post-tensioned work, wires of 0·2 in. and 0·276 in. diameters are most used, and these may not be cold drawn, though in Great Britain they usually are. The price of these high-tensile steels is about two and a half times that of mild steel reinforcement, but as they go at least four times as far, there is some saving in cost as well as much in tonnage.

The strength of the concrete used for prestressing is about twice that for normal reinforced work and is tending to go higher. Under the Reinforced Concrete Code, the maximum permissible working stress in compression for a 1 : 1½ : 3 concrete is 1,250 lb. per sq. in. In prestressed work this grade of concrete would be stressed at 2,000–2,500 lb. per sq. in., the increased strength being obtained mainly by using a smaller quantity of mixing water and powerful vibration of the concrete mix to ensure proper consolidation. By these means cube strengths at an age of 28 days of 7,000–10,000 lb. per sq. in. are obtained, provided the aggregates are suitable and are properly graded and proportioned. It should be noted that the increased strengths are obtained by using less mixing water and providing mechanical means for compacting the drier mix, and not by increasing the cement content. In factory production work it is valuable to release the moulds and stressing beds quickly for re-use. Concrete strengths of 4,000–5,000 lb. per sq. in. are required before the pre-tensioned wires can be released and the concrete prestressed. These strengths are easily obtainable in one day if steam heating or aluminous cement is used. With normal cement, four to five days are required, though this time can be halved by using an admixture of calcium chloride.

## Economics and Uses

It will be seen that the steel and concrete do not cost more than for reinforced work, but the tensioning and the provision for early hardening do add something to the cost; also moulds have to be strong to resist the vibration. On the other hand, the arrangement of cables and wires is usually simpler than reinforcement, and in small bonded members it is usually unnecessary to provide any stirrups, links or bent-up bars. Again, the high-tensioned wires are easily and accurately held in position by the mould end-plates, which are drilled suitably. It is not surprising then that, even in these comparatively early days of development, the cost of prestressed work can compete with alternatives in steel or reinforced concrete. On the Continent, where many large prestressed structures have been built during the past eighteen years, the contracts have usually been obtained in competition with those alternatives.

In a brief article, it is not possible to describe or illustrate the great variety of work that has already been done in prestressed concrete, and which includes a large number of bridges with single or multiple spans up to 250 ft., numerous buildings with roof



*Pre-stressed Concrete Co., Ltd.*

Fig. 5. Esbly Bridge, France, by Freyssinet

girders up to 200 ft. in clear span, large quays and reservoirs, airport runways and road slabs, tunnels and pipes, pylons and posts, sleepers and piles and innumerable joists, beams and slabs for building work of all kinds. Fig. 5 shows the Esbly Bridge over the Marne by Freyssinet, which is of 250 ft. span and is composed of short precast sections connected together by the prestressing cables. The Sclayn Bridge over the Meuse, by Magnel, is a two-span continuous structure formed as a hollow slab with the cables inside: the main spans are each 206 ft. long. An excellent example of a large, light prestressed roof structure is now just being completed at London Airport, Heathrow, where main girders over hangar doors are of 150 ft. span and the roof beams, 110 ft. long and 5 ft. deep, have webs only 4 in. thick.

Most of the benefits secured by prestressing spring directly from the elimination of cracking in the concrete. It has already been shown how this secures important economies in the materials, both by enabling the whole concrete section to be used and by enabling both steel and concrete to be worked at higher stresses than formerly. High-strength concrete free from any liability to cracking is clearly suitable for liquid-retaining structures, and many very large reservoirs and pipes of large diameter, etc., have been prestressed.

The presence of a permanent compressive force acting on prestressed members gives them a resilience akin to timber, and this is a characteristic which at once distinguishes prestressed from reinforced concrete and enables the former to be so much more safely handled—or indeed mishandled. Cracks caused by excessive loading close immediately the overload is removed, and it is doubtless this same characteristic which gives prestressed concrete a much higher fatigue resistance, as is so well exemplified in main-line railway sleepers, which have never been successful in ordinary reinforced concrete.

Because the whole section is in compression and, therefore, doing useful work when loaded, a prestressed member has greater stiffness than a reinforced section of the same dimensions; thus, for the same load, thinner and lighter sections can be employed. This has proved of great value in bridge and girder work, and in round terms has doubled the practicable spans available to reinforced concrete. Lastly, the prestress increases the shear resistance of a beam; if applied in two directions it completely eliminates shear stress. In practice, small prestressed beams require no shear reinforcement.

This all too brief discussion will have indicated the immense possibilities of this powerful technique, which is only on the threshold of development. The next decade may mark swift further strides, and probably the application of prestressing to other materials.

## SOFT MAGNETIC MATERIALS IN TELECOMMUNICATIONS

DURING the past few years developments in the field of soft magnetic materials have been exceedingly rapid, and it is only necessary to compare the performance of 'Supermalloy', the various ferrites and the oriented sheet and strip materials, now in common use, with that of the magnetic substances available a quarter of a century ago, to realize how substantial this progress has been. Although some binary nickel–iron alloys had been investigated at the turn of the century, it was not until the comprehensive work of Yensen and of Arnold and Elmen thirty years ago that the possibilities of these alloys became apparent.

It was thought that it would be useful at this time if academic workers, manufacturers and users could be brought together to discuss one another's problems and to hear of the advances made in the different fields. Arrangements were therefore made to hold discussions during April 3–4 at the Post Office Engineering Research Station, Dollis Hill, London, the subject being "Soft Magnetic Materials whose Properties are of Use or Significance in Telecommunications". The meetings were attended by about seventy people from Great Britain and the Continent, who were briefly welcomed by Brigadier L. H. Harris, controller of research, Post Office. Thirty-four papers were presented, and, as these had been available before the meetings opened, discussions were able to start after only a few words from the respective authors. Four sessions were held: Brigadier Harris presided over the first, and the others were in the charge of Profs. W. Sucksmith, L. F. Bates and E. B. Moullin.

With such a restricted field to cover, it would not have been surprising had there been considerable overlapping. But, in fact, authors had approached the subject from so many different angles that it was not always possible to group papers for common discussion. Both theoretical and practical aspects of the subject were covered, and the discussion was lively and informed. It is perhaps an indication of the interest in the subject that a number of enthusiasts went to a continuation meeting held on the morning of April 5 to complete discussions which had had to be cut short on the previous days.

Except for a few papers which dealt with aspects of the matter not generally considered by telecommunications engineers, the authors concentrated on the following main lines: theoretical consequences of domain structure; the mechanism of magnetic losses, particularly 'residual loss'; extremely high permeability materials; powder cores; ferrites; materials having rectangular hysteresis loops; and methods of measurement.

Powder cores, although first suggested by Heaviside, who took out a patent describing their manufacture and use, are still being developed, and the reasons for the superior performance of certain types of carbonyl iron were discussed. The structure of the material is not fully understood; it is peculiar in that it is built up of heterogeneous particles, severely stressed, yet any step taken to purify it and to relieve stress is accompanied by an increase instead of a decrease in magnetic loss. In iron powder cores, decrease in particle size is accompanied by decrease in hysteresis loss, though this does not hold for those nickel–iron powder cores which are heat-treated after pressing to develop their magnetic properties. Between the powder cores proper and laminated cores is a laminated powder core developed during the Second World War.

During the past few years industry has had available a new, extremely high permeability material known as 'Supermalloy', which may have an initial permeability as high as 100,000 and a maximum permeability of more than a million. The substance has been shown to be a special case of a family of alloys having nearly zero magnetostriction and anisotropy, which are capable of forming superlattices: the high permeability results from partial

ordering of the alloy produced by a critical heat treatment. 'Supermalloy' is a ternary nickel–iron–molybdenum alloy; other members of the family contain copper also, but all have comparable magnetic properties.

The effect of impurities in high-permeability materials was discussed both on the basis of a simple theoretical model and with regard to the control which could be effected in manufacture. Surface layers, produced during either rolling or annealing (their exact source is not yet certain), often reduce the permeability of thin laminations of these materials. This effect and the reasons for it were fully discussed.

There is at present a considerable interest in magnetic materials having rectangular hysteresis loops and combining high remanence (more than 95 per cent of the saturation flux density) with low coercivity. The alloys generally used are the silicon–irons, nickel–irons and cobalt–nickel–irons. They may be either grain-oriented by cold rolling, followed by suitable heat treatment, or domain-oriented by annealing in a magnetic field, and they present interesting problems in measuring their performance. They are used in magnetic amplifiers, mechanical rectifiers, delay lines and switching devices.

Since the introduction of the complex ferrites, such as zinc–manganese ferrite, by Snoek and his colleagues, they have found many applications in telecommunications when moderately high permeability combined with high resistivity is needed. These materials have opened up new fields of study: their magnetic losses differ in some ways from those of the more normal ferro-magnetics; their high resistivity permits measurements to be made in the microwave region without trouble from eddy currents. Measurements of this nature have shown that, with increasing frequency, permeability tends to unity and resonance effects occur which are consistent with the theoretical work of Néel and his associates.

The customary separation of alternating-current losses into hysteresis, eddy current and 'residual' loss was shown to be unsatisfactory in several ways. Hysteresis loss is difficult to define, and if the power factor due to residual loss varies with frequency (as it certainly does), it cannot be clearly distinguished from eddy-current loss. The residual loss itself may have several components, and an interesting difference came to light between the French and German schools of thought on this subject. A source of loss recognized by both is the rapid migration of impurities within the crystal lattice (Snoek's 'disaccommodation'), giving rise to a strongly temperature-dependent loss. Another loss, less dependent on temperature, is thought by the German workers to be due to thermal effects accompanying magnetostriction, but by the French (and some British) workers to be due to thermally activated movement of domain walls. During discussion of these theories, a crucial experiment (measurement of A.C. loss in the presence of D.C. polarization) was devised for distinguishing between them, and it will shortly be tried on various materials. Although these effects are of technical interest mainly when they appear as A.C. losses, they are also observable at slow changes of D.C. magnetization, and some results were quoted of observations over periods of hours which can to some extent, though not fully, be reconciled with the known A.C. effects.

Several papers reported excess eddy-current losses, usually in material having well-aligned domains, including the rectangular loop materials. The measurements were all at low flux densities, and the effect may, or may not, be the same as the 'eddy-current anomaly' known in power engineering, for which another explanation was suggested. This excess loss may be the result of concentrating the eddy-current loss in the regions close to domain walls instead of distributing it uniformly through the material. A further suggestion was that non-uniform flux gives rise not only to excess eddy-current loss, but also residual loss.

Specialized methods of measurement have been developed to study such problems as the variation of permeability through the thickness of strips of high-permeability nickel–iron alloys. Two laboratories have made measurements at frequencies of the order of 10 Mc./s. at which only the surface layers of the material are effective; other studies have been made by measurement after electro-polishing of the strips and by metallographic examination of cross-sections. Some differences between results may be due to differences between British, French and German material, and exchanges of specimens have been arranged.

Several papers discussed the harmonic distortion and the intermodulation produced by magnetic cores. Some materials can produce intermodulation but not harmonics, so that the definition of 'linearity' requires close attention. Experiments have shown that the hysteresis loss due to two superposed signals may be less than that due to the two separately; this, however, can be explained by well-known theory.

A criticism of much work reported (not only at this meeting) by physicists and engineers is that they cannot describe adequately the materials with which they are working. They are generally dependent for supplies on industrialists who do not always realize how much help they could give by describing precisely the samples of materials which they so often generously give to academic workers for research. It is, for example, often difficult to decide from published work just what nickel–iron alloy has been used; the same name may describe different alloys in different countries, and, in fact, different alloys in one country at different times.

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# OBITUARY

## Sir Charles Inglis, O.B.E., F.R.S.

Sir Charles Edward Inglis, emeritus professor of mechanical sciences in the University of Cambridge, who died on April 19 at the age of seventy-six, was probably the greatest teacher of engineering of our day. His powers as a lecturer were unrivalled, as many, outside Cambridge, will know from the lectures he gave before the local centres of the professional engineering institutions throughout Great Britain. Especially to an academic audience, he gave the appearance that what he most wanted to do at that moment was to give that lecture to that particular audience. He loved teaching, and much of the success of his lectures was due to the enormous amount of work he devoted to preparing them; then he spoke fluently and to all appearances without a note.

His power of attracting the love and admiration of all his undergraduates was the greatest of all his

outstanding qualities. For many years past there were fully two hundred new undergraduates each year, and thus only a few of them could have known him personally outside the lecture room: and yet it is true that all of them regarded him as the centre and genius of the place. Whenever one met Cambridge engineers, from any part of the world, their first questions were, in this order: "How is Professor Inglis, how is my College, how is Cambridge and how is the Engineering Laboratory?"

Throughout his life Inglis was keenly interested in problems of education. He became a lecturer at the Engineering Laboratory at Cambridge in 1902 and was a strong influence in developing the Tripos course, the general pattern of which had been started by Ewing in the middle 'nineties. After seventeen years spent in the development of the School, he was called to be head of it in 1919 and continued as such until 1943. Thus it is scarcely surprising that the change of headship from Bertram Hopkinson to Inglis was not accompanied by any marked innovations in the general policy of the Tripos course. Together they had developed the academic discipline which Ewing had initiated, and Inglis, firm in his belief in it, allowed it to evolve steadily throughout his time. It was a discipline which laid great stress on making the undergraduate work out endless problems completely, and to become very practised in the application of the fundamental principles he was taught. It succeeded in giving engineering graduates from Cambridge certain characteristics and predictable qualities, which have come to be commonly recognized and counted on throughout the years. The engineering profession as a whole knows what to expect and what not to expect from a Cambridge graduate. It can be said with truth that Inglis was no great innovator: perhaps he believed firmly in gradual evolution.

Apparently he did not believe in a highly organized administration in an academic world. Years ago he had been known to say that when people realized that they had no marked original talent or strong interest in particular, then they turned to administration and became great men! In discussing the trials of a head of a university department, he would say that while research went hand in hand with teaching, administration went with neither. It can be said that he detested administration in a university or a research department; but he had great talents as the chairman of public service organizations or on the councils of the professional engineering institutions, and in such settings he may have held different views about administration.

Much of the day-to-day detail of the Department of Engineering at Cambridge was attended to very ably by his friend Mr. J. W. Landon, of Clare College, who was secretary of the Faculty Board of Engineering for very many years, and by Mr. A. H. Chapman, secretary of the Department. Landon and Inglis faced together the enormous task of expanding the Cambridge School to meet the demands made on it after the First World War, necessitating the move from Free School Lane to new laboratories built on the Scroope House site, which contained the Department adequately until another war made further expansion essential. He showed great insight in persuading the War Office to send the young officers of the Royal Engineers to Cambridge to read for the Tripos.

To the last Inglis remained an active research worker and could be found on any morning recently still engaged on those meticulous calculations which brought him so much satisfaction. His work on vibrations, particularly his monumental research for the Bridge Stress Committee, is likely to influence engineering science most; but he made important contributions in other fields, notably his early paper on the stresses near an elliptic hole and his work on flat plates for the Institution of Naval Architects.

Though a scholar, Inglis was essentially an engineer and was not afraid of the practical difficulties inherent in most engineering problems, as shown by his development of the once-famous Inglis military bridge, and as is known by the many firms who called on his services. He derived great satisfaction from his engineering contacts and was most happy as a member of Council of the Institution of Civil Engineers, of which he became president in 1941.

The last year of his life was almost as active as any. He had the satisfaction of seeing the publication of his book "Applied Mechanics for Engineers", which contains his elementary teaching on that subject, and of spending three months in South Africa as a visiting lecturer to the University of the Witwatersrand, continuing, what he did so superlatively well and loved so much, the teaching and inspiration of the young engineer.

Undoubtedly Inglis was born with very great gifts; but what mattered most was that, by his own self-discipline, he developed them very fully. He threw the whole of himself into what he was doing at any given moment and never lived at a low intensity. He did many things, and everything with distinction. He was an entertaining conversationalist, but recollection shows that he seldom talked about himself, though very commonly about things he had encountered. He was not one to pass strictures on people, though sometimes he spoke in condemnation of those who did not trouble to prepare their lectures adequately. His character seems to be made coherent if it is credited with an intense humility, which must not be construed as humbleness. He had a profound respect for the dignity of human beings; if men chose to go with him, then he was delighted; if they did not choose to do so, he did not bother them. He never preached at people nor did he proclaim his ideals: these he made apparent from his own personal example. Always mindful of others, he was incapable of actions which were consciously selfish and he was not self-centred. He inspired all the laboratory assistants with a trust which was absolute; and they responded with a loyalty appropriate thereto. When he was not giving the whole of himself to some person his natural preoccupation often made him appear detached, even aloof; this preoccupation was inevitable in a man who had so many interests and occupations. Because he was always calm and not apparently over-worked, some people may not have realized that he was always attending to several different jobs simultaneously.

In July 1950 Inglis spoke to a gathering of old pupils who had met to honour him: much that he said was very characteristic of his happy buoyant nature: "Spontaneous generosity of mind is one of the highest of human attributes and it is all too rare". "Our ambition was to teach you to think for yourselves, to develop your reasoning powers rather than your memories, and to give you the power to strike out with equal facility along any line your future career might take you." "It is not by costly equipment but by the inspiring personalities of the

teaching staff, and by the competence of the laboratory assistants, that the best results in education are achieved. Teaching ability is a rare and priceless commodity, and when you have found a first-class teacher give him his head and don't cramp his style with any soul-destroying examination syllabus." "I know the young are apt to pity old age, but there, as in many other ways, they are all wrong. Spring is glorious, and full of promise; summer is garish and a bit vulgar; autumn is, to my mind, the best part of the year. In the autumn of life one has acquired a sense of values—one has learnt to appreciate a lot one did not discern in the spring time."

He was very proud of our great and learned profession; and that profession, in which he moved naturally in his own right as an eminent engineer, was very proud of him. Moreover, it knows full well how much it owes to Charles Inglis.

This is not the place to list his many practical achievements or his continuous output of research or his chairmanships of boards or of committees, whether engineering or political. His life is too widespread to recount here: in this respect, at least, he had much in common with Keynes, Clapham and Barcroft, his peers and close contemporaries in King's College. E. B. Moullin

# NEWS and VIEWS

## Education and Psychology at Exeter: Prof. S. H. Watkins

Prof. S. H. Watkins, holder of the chair of education and psychology in the University College of the South-West of England, Exeter, is retiring at the end of this session. Prof. Watkins went from Cardiff to Exeter in 1923, succeeding Prof. Wortley, the first occupant of the chair, who held it for only four years before he went as principal to the then University College of Nottingham; the Department of Education and Psychology at Exeter is therefore, to all intents and purposes, Prof. Watkins's creation. Prof. Watkins, who had studied under Wunt at Leipzig, has remained an experimental psychologist, and has increasingly stood aloof from the more modern trends, distrusting (perhaps with good reason) the statistical developments of recent years. At Exeter, while he founded no school, his influence has been considerable. Generations of undergraduates have learnt more from personal contact with him than they have, perhaps, been aware. He has always been easy of approach. But it is probably his colleagues in the Department who have been most influenced. His readiness to listen to the development of an idea and then his sudden and unerring descent on the weak spot in the argument—all done with an engagingly genial air—must have helped many to develop to the full their own line of thought. His influence is perhaps to be detected in the number of his former colleagues who are now occupying chairs in other universities or university colleges, or important administrative positions in the educational world at home and abroad. For Prof. Watkins education is a concrete thing, not abstract and remote, and it is for this reason that the work of the Department is human and not acrid. He has done much to bring the University College and the area which it serves into close and cordial relationship and has served on the Devon County Education Committee. As deputy principal, and now acting principal of the College, and warden of Mardon Hall, his influence has not been confined to the Department of which he is head; during long years of administrative activity he has also greatly served the whole College, and played no small part in evolving the policy of a future University of Exeter.

## Dr. A. C. T. W. Curle

Dr. A. C. T. W. Curle, who has been appointed to succeed Prof. S. H. Watkins, went up to New College, Oxford, in 1935, where he read history and anthropology. In 1938 he was elected, first, Coltant exhibitioner and later scholar in anthropology of Exeter College, Oxford, and made field trips to Lapland and the Middle East while working for a research degree in the Oxford Institute of Social Anthropology. At the end of the Second World War he became senior research officer to the Army Civil Resettlement Department, and in this capacity, and later as a staff member of the Tavistock Institute of Human Relations, he has been applying the sort of methods used in the study of primitive communities, coupled with psychological techniques, to investigate problems of contemporary European society. Dr. Curle was appointed University lecturer in social psychology at Oxford in 1950, and has since been working in the University Institute of Experimental Psychology, where he has done much to bring about closer relationships between the social and biological aspects of psychological inquiry. During this time he has also been editing and co-ordinating the community studies carried out as part of Unesco's Tensions project, and has visited Germany on behalf of the Foreign Office to lecture on recent developments in social psychology in Britain. His outstanding work in both primitive and modern society has led him to believe that problems of intellectual development and emotional adjustment in a rapidly changing society like our own can best be met by the application of sociological and psychological findings to educational matters. Dr. Curle will be greatly missed at Oxford, both academically and personally.

## Unesco Science Writing Prize: Prince Louis de Broglie

The first award of the Kalinga Prize given by Unesco for the best work in the field of popularization of science has been made to Prince Louis de Broglie, for his outstanding contributions to the popular interpretation of science. The Prize was established last year by Mr. M. B. Patnaik, a leading Indian industrialist, as a means of focusing attention on the need for greater understanding and broader use of science for human welfare. Prince de Broglie is known both for research in theoretical physics and for pioneer achievements in the popularization of science; he is the honorary president of the French Association of Science Writers and the permanent secretary of the Paris Academy of Sciences. The jury for the 1952 Kalinga award consisted of three members: Dr. Göran Liljenstrand, of the Caroline Institute in Stockholm, and Prof. M. N. Saha, professor of physics in the University of Calcutta, both selected by the International Council of Scientific Unions, and M. Paul Gaultier, member of the Institut de France, chosen by Unesco. The Prize,

which is of the value of £1,000, bears the name of Kalinga, the empire which covered part of India and Indonesia three centuries before the Christian era.

## Royal Geographical Society : Awards for 1952

HER MAJESTY THE QUEEN has been pleased to approve the award of the Royal Medals as follows : *Founder's Medal*, to Mr. H. W. Tilman, for his exploratory work among the mountains of East Africa and Central Asia ; *Patron's Medal*, to M. Paul-Émile Victor, for his contributions to Polar exploration, including his geophysical investigations of the Greenland ice-cap. The Council has made the following awards : *Murchison Grant*, to Mr. W. D. C. Wiggins, deputy director of Colonial Surveys, for his contributions to Colonial cartography ; *Back Grant*, to Dr. H. F. P. Herdman, senior scientific officer in *Discovery II*, for his oceanographical work in the Southern Ocean ; *Cuthbert Peek Grant*, to Mr. P. H. T. Beckett, leader of the Oxford University Expedition to Persia, 1950, for geographical work ; *Gill Memorial*, to Mr. R. S. Webb, for his contribution to the study of Basuto place-names, and his "Gazetteer of Basutoland".

## Linnean Society of London : Anniversary Meeting

AT the anniversary meeting of the Linnean Society of London, held on May 24, the Linnean Gold Medal was awarded to Mr. I. H. Burkill, director of the Botanic Gardens, Straits Settlements, during 1912–25. The following were elected officers for the session 1952–53 : *President*, Lieut.-Colonel R. B. Seymour Sewell ; *Treasurer*, Colonel F. C. Stern ; *Secretaries*, (Zoology) Dr. A. Tindell Hopwood, (Botany) Dr. George Taylor ; *New Members of Council*, Mr. J. E. Dandy, Dr. S. M. Manton, Prof. P. B. Medawar, Mr. E. Milne-Redhead and Dr. W. E. Swinton. Prof. Lothar Geitler, of the Botanical Institute, University of Vienna, and Dr. Ernst Mayr, of the American Museum of Natural History, New York, were elected foreign members. The Rev. S. G. Brade-Birks, Mr. H. Gilbert-Carter and Mr. G. W. Robinson were elected associates *honoris causa*.

## University of London

THE following appointments in the University of London have been announced : Prof. V. C. A. Ferraro, professor of applied mathematics in University College, Exeter, to the University chair of mathematics tenable at Queen Mary College from October 1 ; Dr. P. C. C. Garnham, to the University chair of medical protozoology tenable at the London School of Hygiene and Tropical Medicine from October 1 ; Mr. J. A. B. Gray, of the National Institute for Medical Research, to the University readership in physiology tenable at University College from October 1. The title of reader in technical optics in the University has been conferred on Mr. B. K. Johnson in respect of the post held by him at the Imperial College of Science and Technology. The following doctorates have been conferred : *D.Sc.*, Izrael Hieger (Royal Cancer Hospital) ; D. S. Kettle (University College) ; John O'Mara-Bockris (Imperial College of Science and Technology).

## Mellon Foundation : Research Fellowship in Artists' Materials

THE thirty-eighth annual report of the president of the Mellon Institute—that for 1950–51—contains a brief but significant reference to the new fellowship, awarded to Dr. R. L. Feller, for development of "new materials and techniques for the fine arts, both for use in original work and for restoration, with a special view towards permanence". The fact that important advances have been made in recent years in our knowledge of materials (oils, pigments, and so forth) should not excuse the relatively minor benefits which have so far been conferred upon the artist and sculptor. The very special and delicate problems associated with the conservation of works of art—of all kinds—have received too little attention. These questions are the cause of much proper anxiety to museum and gallery authorities. The tendency of varnish to yellow, and its propensity of blooming are examples. Many others could be quoted, once classical paintings are conceived as a stratified system (support–ground–paint–varnish) and the interrelations of the layers examined. In all this, the new developments at the Mellon Institute will be watched with the keenest interest.

Perhaps it is not inappropriate to note that this recent venture coincides approximately with the setting up—with headquarters in London—of the International Institute for the Conservation of Museum Objects, a project originally conceived in New England, and now endeavouring to make known to scholars and conservators the fruits of scientific investigations applied to the fine arts. The *Carnegie Magazine* (January and February 1952) contains contributions relevant to these special activities, both those of Dr. Feller and those of the new Institute for Conservation in London. They are indicative of a serious awakening to the value of prophylactic treatment, and a stimulus to renewed efforts towards the mastery over materials.

## Boyle and Alchemy

CONCERNING Robert Boyle even the smallest fact is of interest. In 1684 Weidenfeld published a work entitled "De Secretis Adeptorum Sive De Usu Spiritus Vini Lulliani Libri IV". This work is dedicated to the "most illustrious Robert Boyle of the Royal Society" and contains, at the end of the table of contents of the first book, a list of eight "writings of the adepts not yet printed by the Maecenates of the art, imparted to me by patrons and friends for the common good". Among these titles is "De Magisterio, sive de investigatione secreti occulti Lullii : ab illustri Domino Roberto Boyleo". According to the dedication, Weidenfeld, who lived at Vilna, heard of Boyle, and came to England to visit him. Boyle received him kindly, praised his studies and thereby "raised his mind to greater things". Apparently he also presented him with this manuscript on the Lullian type of alchemy (Thorndike, L., "History of Magic and Experimental Science", Vol. 4, pp. 3–65 ; Sherwood Taylor, F., "The Alchemists", pp. 109–122 ; New York, 1949). Boyle's attitude to alchemy was ambivalent, as is seen, on one hand, by his criticisms in the "Sceptical Chymist" and elsewhere, and on the other by his "Historical Account of a Degradation of Gold, Made by an Anti-Elixir. A Strange Chymical Narrative" (Fulton, No. 137). His possession of this alchemical manuscript and his willingness to give it away may serve as a measure of his interest in such matters.

## *Applied Statistics* : New Journal of the Royal Statistical Society

THE Royal Statistical Society has just started a third journal, *Applied Statistics*, which will deal with

the application of statistical methods in industry, commerce and science. The development of statistics in recent years is well reflected in the evolution of the Society and its publications; its membership, which is still increasing steadily, is more than double the pre-war figure. Its main journal has already split into two, one for the main activities of the Society and one for its Research Section. Two other offshoots of the Society, its Industrial Applications Section and Study Section, have hitherto had no separate journal, and *Applied Statistics*, though not confined to the activities of these groups, takes its keynote from them. The object of the new journal is to present simply and clearly the statistical approach and its value, not merely to professional statisticians, but to all workers concerned with statistical methods. It will publish short technical articles, but will also cater for the statistical layman working in such diverse fields as chemistry, engineering, agriculture, scientific management and sociology. In a foreword to the first issue Prof. A. Bradford Hill very rightly says that so many scientific journals exist that anyone founding a new one must have a cast-iron case. There can be little doubt about the strength of the case for *Applied Statistics*. Statistical methods are used more widely and more successfully in industry and science in Great Britain than in any other country in the world, and this new journal is not so much a venture as a response to an insistent demand. The Society is to be congratulated on finding among its fellowship a strong editorial committee, headed by Mr. L. H. C. Tippett, to carry out the important task of bridging the gap between the producers and consumers of statistical methods.

## Latin-American Forestry Commission: Session in Buenos Aires

The fourth session of the Latin-American Forestry Commission will be held in Buenos Aires during June 16–21 under the joint sponsorship of the Argentinian Government and the United Nations Food and Agriculture Organization. The Commission was set up as a result of a recommendation made by the Latin-American Conference on Forestry and Forest Products, held in Brazil in 1948; previous sessions were in Rio de Janeiro in May 1949, Lima in November 1949, and Santiago in December 1950. One of the principal items to be discussed will be the possibility of setting up a Latin-American forest research and training institute. Other matters with which the Commission will be concerned are the production, consumption and trade of pulp and paper and also the Technical Assistance Programme which the Food and Agriculture Organization is carrying out in Latin America. Finally, the Commission will review the steps to be taken to prepare for the next World Forestry Congress, due to be held in 1954. Further details of the session in Buenos Aires can be obtained from the Food and Agriculture Organization at Viale delle Terme di Caracalla, Rome, or at one of its regional offices.

## Hungarian Biological Association

At the inaugural meeting of the Hungarian Biological Association, held at the Hungarian Academy of Sciences on March 30, the following officers were elected: *President*, Prof. S. Jávorka; *Vice-Presidents*, Academicians S. Kotlán, E. Dudich, J. Gelei and R. Mancha, and Profs. D. Fehér and S. Sárkány; *Secretary-General*, I. Boros; and *Assistant Secretary*, J. Ujhelyi. During the meeting, N. G. Potapov, director of the Botanical Institute of the Loránt Eötvös University of Science, gave a lecture on "The Role of Roots in Plant Life".

## The Night Sky in June

Full moon occurs on June 8d. 05h. 07m., U.T., and new moon on June 22d. 08h. 45m. The following conjunctions with the moon take place: June 3d. 09h., Saturn 7° N.; June 5d. 01h., Mars 4° N.; June 18d. 14h., Jupiter 6° S.; June 23d. 20h., Mercury 0·9° S.; June 30d. 18h., Saturn 7° N. Mercury is in superior conjunction on June 9, after which it becomes an evening star, setting at 21h. and 21h. 40m. on June 15 and 30, respectively. Venus, in superior conjunction on June 24, is too close to the sun throughout the month for favourable observation. Mars is visible until the early morning hours, setting at 2h. 10m., 1h. 10m. and 0h. 15m. at the beginning, middle and end of the month, respectively. The planet is a little south of $\varkappa$ Virginis during June, and its stellar magnitude decreases from $-1{\cdot}1$ to $-0{\cdot}5$ between June 1 and 30. Jupiter, a morning star, rises at 2h. 40m., 1h. 50m. and 0h. 55m. on June 1, 15 and 30, respectively, its stellar magnitude remaining about $-1{\cdot}6$ throughout the month. Saturn sets in the early morning hours, at 1h. 50m., 0h. 55m. and 23h. 55m. on June 1, 15 and 30, respectively, and throughout the month can be seen very close to $\gamma$ Virginis. No occultations of stars brighter than magnitude 6 take place during June, but the conjunction of Mercury with the sun, as already mentioned, is actually on June 23d. 20h. 23·6m. Summer solstice occurs on June 21d. 11h.

## Announcements

The Physical Society's summer provincial meeting will be held this year in the Department of Natural Philosophy, University of Glasgow, during July 10–11. The subject of the meeting, which will be divided into four sessions, will be "Nuclear Fundamental Particle Physics". Visitors wishing to attend this meeting should apply before June 25 to the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

A symposium on "Concrete Shell Roof Construction", organized by the Cement and Concrete Association, will be held during July 2–4. On the first day the papers will deal with the architectural aspect of concrete shell roofs and will be given at the Royal Institute of British Architects. The second and third days of the symposium will be held at the Institution of Civil Engineers and will be devoted to design and research, and construction respectively. All papers will be circulated in advance. Membership of the symposium is free to all. Application should be made to the Organizing Secretary, Symposium on Concrete Shell Roof Construction, Cement and Concrete Association, 52 Grosvenor Gardens, London, S.W.1.

A further part, No. 5, January–June 1951, of the "Bibliography of Scientific Publications of South Asia (India, Burma, Ceylon)" has been issued by the South Asia Science Co-operation Office, Delhi (pp. 97, 1952). It contains 2,436 entries, as well as supplementary lists of sixteen new scientific periodicals in India and one in Ceylon. Changes of name, frequency of appearance or publishers' address of six periodicals previously listed are noted. The Office has also issued a name index (pp. 48; 1951) to the first four numbers (1949–50) of the Bibliography.

# RESONANCE IN GYRO-INTERACTION OF RADIO WAVES

By Prof. V. A. BAILEY, R. A. SMITH, K. LANDECKER, A. J. HIGGS and F. H. HIBBERD
Department of Physics, University of Sydney

In a series of publications[1-4] by one of us (V. A. B.), it was shown that under certain specified conditions a low-power modulated wave $A$ of frequency $f$ within a few per cent of the local gyro-frequency (termed a gyro-wave) could impress on a suitably selected second sky-wave $B$, reflected in its neighbourhood, a notable amount of its own modulation, and that as the frequency $f$ of the gyro-wave passes through the gyro-frequency $f_H$ a notable degree of resonance may occur.

The first of these predictions was amply confirmed by the experiments made in March 1937 with the collaboration of many British and other authorities and observers[5]. These experiments also yielded some evidence in support of the prediction of resonance.

The approximate form of the resonance curve which the theory predicts is illustrated by Fig. 1, which is a reproduction of the Fig. 3 given in one of the publications cited[3]. This figure shows that the resonance curve will have one hump or two humps according as the wave $B$ (usually called the wanted wave) is mostly absorbed at the lower or higher levels of a slab $S$ of the $E$-layer which extends approximately 90–95 km. above the ground.

This prediction was tested by M. Cutolo and collaborators in a series of remarkable experiments[6-8] carried out in Italy during 1946–50. As a result, they found resonance curves with two humps lying equidistant from the local gyro-frequency.

During the same period experiments were carried out by L. G. H. Huxley[9], J. A. Ratcliffe[10] and their respective collaborators, which led them to conclude jointly[11] that resonance near the gyro-frequency does not occur. More recently, I. J. Shaw[12] carried out experiments with gyro-waves which led him to the same conclusion. He and Ratcliffe disregarded the essential role of the slab $S$ of the $E$-layer when selecting the experimental conditions under which resonance may be observed.

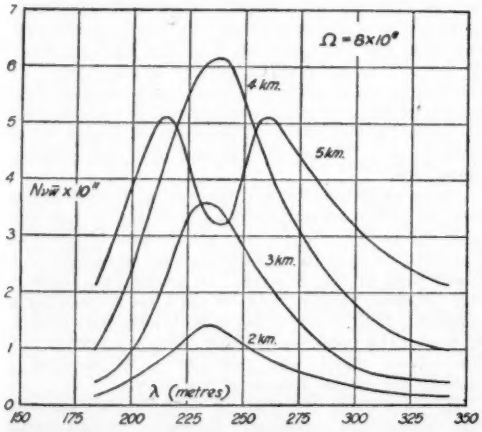


Fig. 1. This is Fig. 3 of Prof. V. A. Bailey's article "On Some Effects caused in the Ionosphere by Electric Waves" (*Phil. Mag.*, Ser. 7, **26**, 425; Oct. 1938)

We shall now describe briefly a series of experiments carried out in Australia during the past two years. These experiments were designed to conform as closely as possible to the requirements of the original theory, and, as will be seen below, the resulting observations have completely confirmed all the theoretical predictions.

The gyro-wave $A$ was radiated vertically from a horizontal aerial situated at Armidale, New South Wales. The wanted wave $B$ was radiated from the national station 4$QR$ at Brisbane, Queensland, at a frequency of 590 kc./s. and with a power of 10 kW. The principal observations of $B$ were made at Katoomba, New South Wales, since Armidale lies almost exactly at the mid-point of the line (740 km. long) joining Brisbane and Katoomba. From the magnetic data for Armidale the local gyro-frequency was estimated to be 1,530 ± 15 kc./s.

The gyro-wave was radiated in the form of square pulses of length 1 msec. and repetition frequency 40 per sec. The radio-frequency $f$ was kept constant for 2 min. at each of the following frequencies—1,255, 1,385, 1,455, 1,530, 1,605, 1,680, 1,755 and 1,880 kc./s.; these lie within ± 23 per cent of the gyro-frequency. The pulse power radiated was kept nearly constant at 36 kW. The experiments were carried out during the early morning between 1 a.m. and 2.20 a.m. standard time for Eastern Australia (that is, local time at 150° east of Greenwich). On each morning the frequency of the wave $A$ ran four times through the following cycle of successive frequencies: 1,530, 1,605, 1,455, 1,680, 1,385 and 1,755 kc./s.; each cycle lasted 17 min. In addition, the fourth cycle was extended by the frequencies 1,880 and 1,255 kc./s. This order of the frequencies was adopted so that any resonance which might be observed could not be attributed to a steady change with time of ionospheric conditions which increased the interaction of $A$ with the wanted wave $B$ and thus caused a bias favourable to the theory. For, any such tendency would then raise the outer ends of the curve relating $M_i$, the observed depth of the impressed pulse, to the frequency $f$. In order to provide a standard of comparison, the wanted wave $B$ was modulated for 30 sec. in each 2-min. period with a standard tone of 80 c./s. to a depth of 5 per cent.

The method of observation was as follows. Two radio receivers $R_B$ and $R_A$ were tuned respectively to the wanted wave $B$ and the disturbing wave $A$, and their rectified outputs were displayed on the screen of a double-beam cathode-ray oscillograph, the time-base frequency being usually adjusted to 80 c./s. This display and the corresponding time and signal-strength were photographed at intervals of ten seconds. Visual estimates of the impressed modulation $M_i$ and standard modulation of 5 per cent depth were also recorded.

Observations were made at Leura (near Katoomba) on September 6, 7 and 8, 1951, at Hornsby (near Sydney) on October 11, and at Katoomba on October 23, 24 and 25. In addition, continuous photographic observations were made by Mr. R. McNicol, of the University of Queensland, on September 20 at

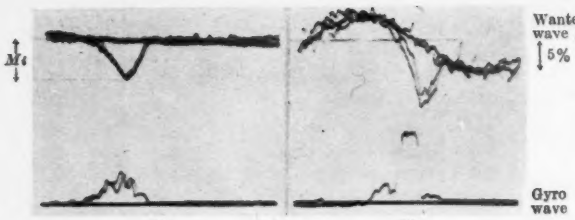


Fig. 2

Somerset Dam, Queensland, the wanted wave being that from station 2*FC* (610 kc./s.; 10 kW.), located near Sydney. All these observations showed conclusively that a notable degree of resonance occurs as the frequency of the disturbing wave $A$ passes through the gyro-frequency within the range $\pm$ 23 per cent. These will be fully described elsewhere, so it is sufficient here to give as typical the results of the observations made at Katoomba on October 24.

Examples of the pulses impressed by $A$ on $B$ are shown by photographs in Fig. 2, with the time increasing from right to left.

In Fig. 2*b* the standard modulation tone of 5 per cent depth and the impressed pulse occur together. The lower traces represent the Armidale pulses as received directly on receiver $R_A$.

The impressed modulations $M_i$ (adjusted so as to relate to the same vertical Poynting flux from the pulse transmitter at all frequencies), represented by the depth of the pulse shown at the top of Fig. 2*a*, were measured from the photographic records and also occasionally from the simultaneously recorded visual estimates whenever the former were obscured by atmospherics. The mean value of $M_i$ corresponding to each frequency in one cycle is shown plotted in Fig. 3. The mean values are, in general, correct to

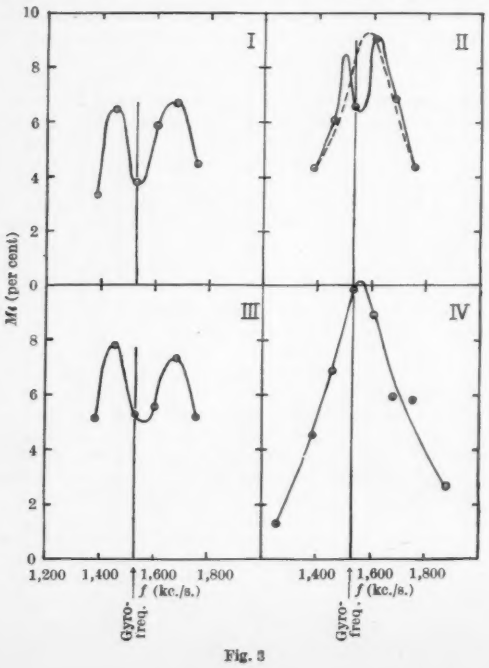


Fig. 3

within 10 per cent or less. The plotted points for each cycle were then joined by means of the curves shown. The curves corresponding to the cycles I and III unmistakably show that two-humped resonance was occurring at the corresponding periods of time. The curve corresponding to cycle IV shows that one-humped resonance occurred in the last period. The conditions during cycle II, as indicated by the signal-strength meter on receiver $R_B$, fluctuated considerably; accordingly, there is some difficulty in deciding whether the corresponding curve has one or two humps. But even these observations show that resonance occurs, for the lowest values of $M_i$ correspond to the lowest and highest frequencies in the cycle. Most of the observations which could be made with comparable accuracy on the other occasions mentioned yielded similar two-humped curves in the earlier cycles and a similar one-humped curve in the last cycle. This behaviour may be attributed theoretically to an increase with time of the mean gradient of electron number-density $N$ in the lower part of the $E$-layer.

In all these resonance curves the minima of the two-humped curves and the maxima of the one-humped curves occurred at frequencies within about 3 per cent of the gyro-frequency (1,530 kc./s.). Thus the theoretical predictions indicated in Fig. 1 are completely confirmed. Cutolo's observation of two-humped resonance is also confirmed.

From twenty clear photographs of pulse shapes (like that in Fig. 1*a*) taken on October 25, we have deduced values of the time constant $1/G\nu$ which range from 0·7 to 1 msec. These are of the same order as the value deduced from the observations on radio-interaction, made by van der Pol and van der Mark[13], and the values obtained by Huxley[9] and Ratcliffe[10].

By means of a more detailed development of the original theory of gyro-interaction by one of us (V. A. B.), it is now possible to derive the following information about the lower part of the $E$-layer from observed resonance curves and shapes of impressed pulses (or from impressed sinusoidal modulations): the strength of the local magnetic field $H$, the collision frequency $\nu$, the coefficient $G$ relating to the energy lost by an electron at a collision with a molecule of the surrounding gas, the temperature of this gas, and the gradient $b$ of the electron-density $N$, when $N$ is assumed to increase exponentially with the height above 90 km. Preliminary calculations by means of some of our observations have given results in general agreement with previous estimates of these quantities. These calculations will be published elsewhere.

These experimental and theoretical results indicate that with further improvements in the means available the study of gyro-interaction may be used as a powerful method for the detailed investigation of the lower part of the $E$-layer. In particular, there is a fair prospect that it may be used for measuring the magnetic field in the $E$-layer with sufficient precision to reveal the presence of those electric currents in the ionosphere which are postulated to account for certain terrestrial magnetic variations.

In conclusion, we wish to acknowledge gratefully the assistance received through Commonwealth research grants and from the following bodies and individuals: the Radio Research Board, the Postmaster General's Department, the Wireless Institute

of Australia, Drs. E. G. Bowen and J. L. Pawsey, Prof. H. Webster, Mr. J. M. Somerville and Mr. T. T. Toakley.


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# MORPHOLOGY OF CRYSTALLIZING POLYMERS


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A CRYSTALLINE unoriented high polymer has generally been regarded as an intimate mixture of amorphous and crystalline regions homogeneously distributed throughout the material. In an oriented fibre the same structure has been visualized with the chain molecules having a preferential direction (for example, see ref. 1). While this picture of the homogeneous amorphous-crystalline composite phase is still accepted as the structure of synthetic polymers, there is an increasing amount of electron-microscopic evidence of a submicroscopic structure in some biological materials (see ref. 2). Even in the field of synthetic polymers, it is known from the work of Bunn and Alcock[3], Bryant[4], Brenschede[5], Jenckel and Wilsing[6] and others that these substances are not optically homogeneous when viewed through the polarizing microscope, but consist of well-defined birefringent regions showing spherulitic extinction patterns.

In a study of the kinetics of crystallization carried out in these laboratories (to be published at some later date) our attention was turned to these spherulites. The investigation which followed revealed a great variety of structural units of definite physical individuality, of submicroscopic and microscopic dimensions. Most of the work was carried out on polyethylene terephthalate, though some work has been done on other polymers. Here the results of the first stage of this work will be summarized.

In the case of polyethylene terephthalate, we confirmed that the development of crystallinity is associated with the formation and growth of spherulites. X-ray examination showed that the spherulites are the crystalline portions, whereas the regions between the growing spherulites gave no crystalline diffraction. The spherulites showed a definite physical individuality and behaved in many ways as separate phases. When a partially crystallized material was treated with suitable solvents, the spherulites remained unchanged while the embedding amorphous material dissolved. In this way the spherulites could be separated. They proved to be mechanically and thermally more resistant, and were translucent in the transparent amorphous medium with incident illumination. In agreement with previous descriptions, a fibrous fine structure was observed.

It was found that the appearance of the spherulites depends on the temperature of their formation. Samples were prepared by fusing the dried polymer in narrow tubes, and by crystallizing the melt by keeping it for varying lengths of time at constant temperatures below the melting range. Polyethylene terephthalate could be crystallized in this way at any temperature between 100° C. and 260° C. Crystallization could be interrupted at any time by quenching. From the quenched solid, thin sections were cut and the structure loosened and strains removed by suitable solvent treatment. Microscopic investigation of two-dimensional, or portions of dissected or disintegrated three-dimensional, spherulites between crossed nicols showed the following effects. Spherulites crystallized at the lowest temperatures (100–130° C.) had the usual spherulitic appearance with a straight black cross. The direction of the largest refractive index was along the radius. When crystallized at higher temperatures, the black cross appeared as zig-zag lines, the angular extension of the zig-zag increasing with temperature of crystallization. Fig. 1 shows a typical example of such spherulites formed at 220° C. When the zig-zags extend over an arc of 90° (239° C.) their ends meet and the spherulite shows concentric black circles and an apparent black cross at 45° to the directions of vibration. Above this latter crystallization temperature the patterns become more complicated. At 260° C. no more spherulites form, but only fibre bundles. The fibrous character of the spherulites increases with increasing temperature of crystallization. In unpolarized light it was observed that the formation of spherulites starts with an airscrew-like aggregation of fibrils which afterwards opens out like a sheaf to form a sphere.

The zig-zag extinction pattern can be most obviously explained as follows. Assuming the direction of one of the main refractive indices (in this case that of the largest) winding with a constant angle describing a helix, and several such helices radiating from one centre, a zig-zag extinction pattern will be obtained between crossed nicols. The angular extension of the zig-zag will be twice the complement of the helical angle, and the radial distance between the end-points of two successive zig-zags will be the pitch-length. According to this picture, at low temperatures of crystallization the helix will be very elongated (nearly a straight line, helical angle $\approx 90°$), giving the straight black cross. At higher crystallization temperatures the helix is getting flatter, increasing the extension of the zig-zag pattern, until at the crystallization temperature of 239° C. the helical angle becomes 45°, resulting in the extinction pattern already described. As the helix flattens further, the number of extinction positions will increase, resulting in a more complicated pattern in agreement with what has been observed at crystallization temperatures higher than 240° C. A completely flat helix (angle $\approx 0°$) would give a normal black cross with a concentric black ring-system. This stage is not reached by polyethylene terephthalate, but has been observed with polyethylene. From the angle and the pitch-length the diameter of the helix can be calculated. The values so obtained ranged from about 250 A. (130° C. crystallization temperature) to about 5 $\mu$ (239° C.

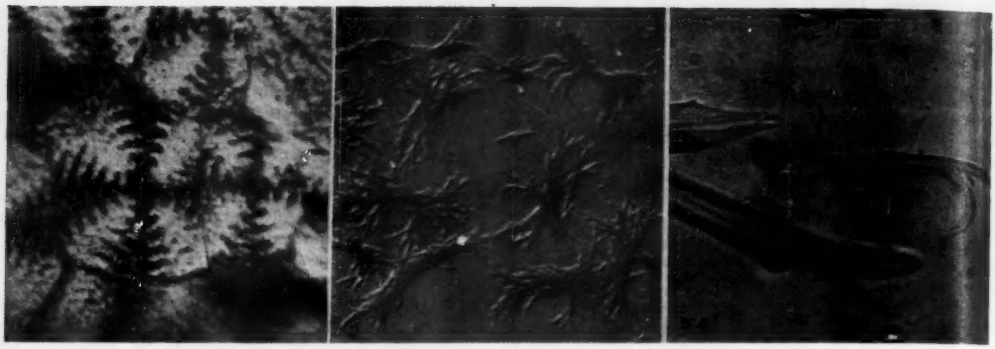

Fig. 1. Spherulites of polyethylene terephthalate formed from the melt at 220° C. Crossed nicols. × 360
Fig. 2. Electron micrograph of solvent-cast polyethylene terephthalate. Gold-shadowed. × 13,300
Fig. 3. Drawn fibres of polyethylene terephthalate disintegrating in *o*-chlorphenol. Unpolarized light. × 350

crystallization temperature) and to bigger but uncertain sizes at still higher temperatures. This agrees with the observed increase of the fibrous character of the spherulites with increasing temperature of crystallization. The fibres formed at the higher temperatures were big enough to be detached and measured under the microscope, and the measured dimensions agreed in magnitude with those which were calculated. In those cases where the fibres could be readily seen through the microscope, they proved to be flat ribbons wound in the form of a helix, which further confirms the reality of the picture proposed for the explanation of the zig-zag extinction pattern. At present nothing definite can be said about the arrangement of the molecules, but only about that of the refractive indices, within these helices. In simple polymers like polyethylene the biggest refractive index can be identified with the chain direction, but with polyethylene terephthalate conditions may be more complicated.

Electron micrographs of solvent-cast polyethylene terephthalate films show fibre bundles (Fig. 2) with fibres of about 500 A. across, sometimes forming airscrew-like aggregations similar to those observed with the optical microscope during crystallization from the melt. The fibrils, apparently cylindrical with a well-defined periodicity along their length, proved to be in reality flat ribbons closely coiled into helices. Consequently the electron microscope showed the same morphological features in the submicroscopic region as the optical microscope showed in the microscopic region.

These facts suggest the following simplified morphological picture of crystallization. At first the molecules form fibrils which are flat and helically coiled ribbons. The relation of these new units to the molecules and to the concept of the crystallites remains to be shown. These fibrils aggregate, and eventually form spherulites, or sometimes bigger fibre bundles.

Drawn fibres of polyethylene terephthalate could be split into smaller units using suitable solvents (Fig. 3). A great variety of microfibrils of all dimensions was observed within the microscopic range. These units were always flat ribbons, often with a tendency to coil into helices. Consequently also a drawn fibre consists of secondary units which are similar to those formed spontaneously from unoriented melts and solutions. This means that drawing may not be simply a molecular process, and that the spontaneous formation of fibres is an inherent property of long-chain molecules. The same conclusion has been reached in a communication by Ribi[7] which appeared while this article was being prepared. Ribi has demonstrated the breakdown of various polymers into fibrils by means of supersonic radiation.

Preliminary work on synthetic polymers other than polyethylene terephthalate, such as polyethylene and polyamides, indicates that the above findings might be general and characteristic—although not always as easily observable—among all these substances. It is obvious that the existence of such complex structural units must be taken into account whenever the physical properties measured on the bulk sample are related to the molecular structure, which is particularly important for technical applications.

Finally, these phenomena may be still more general and not necessarily limited to long-chain compounds. It has been shown by Wallerant[8] and also by numerous studies by Gaubert (for example, see ref. 9) that simple organic substances, minerals and even elements (sulphur) can form spherulites which are built of helically-wound fibres. These authors describe numerous types of helical windings which are somewhat, though not very, different from those observed in synthetic polymers.

I am indebted to Mr. A. C. Cooper for taking the electron micrographs. [Feb. 11.

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## TECHNOLOGICAL EDUCATION

AMONG many interesting items in his last report to the Council of the University of Birmingham, the vice-chancellor, Sir Raymond Priestley, examined the future of technological education in Britain. Britain, he suggests, has lost its lead as an industrial power, and, for remedy, no simple panacea exists. The proposal that Britain should set up a technological university along the lines of the Massachusetts Institute of Technology is, according to Sir Raymond, dangerous both to the nation and its

existing university system. The danger lies in the diversion of a large proportion of already inadequate resources to the duplication, in an entirely different situation, of a type of education which American educationists consider to be already outdated and which they are trying to bring into line with the more conventional type of university. If a technological institute were started *de novo* in Britain to-morrow, it could have no decisive impact upon British industrial structure and output for a quarter of a century at least. In the meantime, the attempt at its establishment would have fatally slowed down the progress of universities and technical colleges alike.

Nor is there sure evidence that such an institution would have the decisive effect its advocates claim. The American senior technological institutes came into existence during a period of expanding economy on a newish continent in a different world. An increasing section of educated American opinion is beginning to suspect they are not so well suited to the stage the country has reached to-day.

In the United States, too, there are no institutions which skim off the cream of national youth with such skill and in such quantity in proportion to total population as Oxford and Cambridge have in the past half-century in Great Britain. This is probably the greatest single obstacle to the solution of the United Kingdom problem of diverting a reasonable proportion of the flower of the nation's educated manhood into engineering development and design—the solving of which is the main objective of the advocates of an English "M.I.T.". The pick of our youth will gravitate to Oxford and Cambridge at the undergraduate stage for a generation to come, and it is inconceivable that these particular universities will allow of the development within their boundaries of great postgraduate applied science schools. The only solution of this dilemma is the development and full exploitation of the graduate school of specialist engineering in the existing civic universities and the colleges of technology.

Sir Raymond also discussed the place of the public school in the education of the engineer. Analysis of the schoolboy entry into the departments of mechanical and civil engineering of the University of Birmingham for the period 1938–51 showed that the percentage of the grammar school entry obtaining first-class honours was nearly double the percentage of the public school entry and nearly three times that of the other secondary schools. Sir Raymond believes that the civic universities do not receive a fair sample of public school men, and that the channelling of brains and character to the public schools must aggravate the already difficult problem of producing sufficient engineers of such quality of mind and personality as will enable them to make their way on to the directorates of the great industrial concerns and to see that the best possible use is made of the genius for invention and design that the nation unquestionably possesses. In the present situation too great a proportion of the *élite* of our youth is likely to pass through the great humanities specialist courses—such as Greats and Modern Greats and the Cambridge Triposes—either to the Civil Service or to research in pure science. More of the best of our youth who combine strong character with high-quality brain should be encouraged to learn mathematics, physics and chemistry at school, and more of them should be directed to universities where engineering is considered to be a legitimate objective for the very best men.

# DOCUMENTATION TECHNIQUES IN THE UNITED STATES

THE report of the team of European experts on documentation techniques who visited the United States during November and December 1950, under the Economic Co-operation Administration Technical Assistance programme, has now been issued as an example of the contribution of the Organization for European Economic Co-operation to the improvement of European economic efficiency in the sphere of selection, reproduction and dissemination of documents*.

The three chapters of the report describe, first, the libraries and information services visited by the team, documentary reproduction techniques used in the United States, and lastly the use of punched cards and analogous techniques. While the report is largely factual, though highly condensed, each chapter includes a clear statement of the conclusions reached by the team and some recommendations; three, involving action by the Organization for European Economic Recovery, being summarized at the end. The first of these relates to the organization by competent authorities in the United States and in member countries of surveys to provide some comparative data about the degree of utilization of technical and scientific information in industrial organizations. Secondly, the report makes a representation to the United States authorities with the view of increasing the availability of 'unclassified' documents from American defence establishments to non-defence organizations in member countries. Thirdly, the import into Europe of equipment, such as special photographic equipment and special typewriters, which are only available in the United States, should also be facilitated.

For the rest of the report, the team notes the great willingness of libraries and information centres in the United States to provide a service to the technical public, as evidenced, for example, by the late hours which some libraries are open in the evening. Study of the use of Library of Congress catalogue cards is recommended as regards the possibilities both of such methods in other countries and of European co-operation in the production of the cards. The report details at some length the team's reasons for considering that micro-photography does not provide a suitable readable medium for the storage and transmission of scientific and technical information, and advocates the development of 'enlarger-scanners' for preparing enlargements of microfilms of interest. It also considers that each area should have centralized automatic facilities for enlarging microfilms so that such material as is only available on microfilms or, through currency difficulties, can be transmitted more rapidly or simply in that way, may be utilized. There appears to be considerable scope for the use of offset lithography; but progress in this field in Europe is limited by the availability of the special equipment required.

Manually sorted punched cards are more widely used in the United States than in Europe for the documentation of technical and scientific literature, but no special developments are reported. The field punched type of cards is also more widely used, both for mechanical listing operations and to facilitate

* Documentation Techniques in the U.S.A.: Selection, Reproduction, Dissemination. Report of a Group of European Experts. Pp. 61. (Paris: Organization for European Economic Co-operation; London: H.M. Stationery Office, 1951.) 4*s*.

selection; and if a standard method of describing series is adopted internationally, extended use of the 'Cardatype' machine in listing serial publications offers an opportunity for co-operation between organizations in different parts of the world in determining the availability of periodicals. The team considers that commercially available selecting machines have achieved nothing that cannot be achieved by traditional methods, although adequate costing data were not obtained and the use of such machines does not eliminate cross-referencing. The future value of the Rapid Selector line of development is also doubtful, but a simplified selector built on the principles of an electronic computor might compete in cost and speed of operation with proposed International Business Machine developments.

## MECHANICAL PROPERTIES OF PLASTICS

UNDER the title of the "Mechanical Properties of Plastics", the Plastics and Polymer Group of the Society of Chemical Industry organized an all-day symposium, held at the Institution of Electrical Engineers, London, on March 7. The considerable interest in the subject was indicated by the fact that some two hundred members and visitors attended, including representatives of the Chemical Engineering Group of the Society. Five papers were presented during the day, and ample time was allocated for the vigorous discussion which followed each contribution.

In a brief introductory summary, Dr. N. J. L. Megson pointed out that since 1939 a revolution has taken place in plastics. The materials are finding increased application to the production of large items having properties not previously considered practicable. Unfortunately, because of a lack of fundamental knowledge, much of the necessary development work has to be done on an empirical basis; a symposium of the present type was therefore justified, even if it only directed attention to the gaps in our knowledge.

Dr. Megson indicated three main categories in which mechanical testing can be approached: the fundamental approach, which seeks to relate molecular shape and size, or the composition of a heterogeneous material, with mechanical behaviour; the assessment of a material for practical use, by determination of properties by means of carefully selected tests; and the empirical approach, which uses mechanical test procedures to compare one material with another or to lay down standards. He thought that, of these, the fundamental approach would be expected to prove of greatest interest at a meeting of this character. Nevertheless, this did not mean that the other categories were unimportant, and, in fact, most of the papers naturally covered more than one category in their scope. It was, of course, obvious that the practical utility of a material (the second category) must be of primary importance to the plastics industry.

In the first paper, on the "Physical Evaluation of Small Samples of Plastics", by K. H. C. Bessant, Mrs. M. G. Dilke, C. E. Hollis and J. J. Millane, Mr. Hollis explained that work had been undertaken to permit the evaluation of experimental samples (5–50 gm.). For hard thermoplastics he described tests for impact strengths, softening-points and flow characteristics, while for elastomers (for example, polyvinyl chloride) he dealt with tensile strength and elongation at break, British Standard hardness, brittle temperatures, resilience and plasticizer loss. With suitable precautions, all these can be carried out with appropriate modifications of existing methods. Reproducibility is sufficient for making significant comparisons between laboratory samples. This paper provoked questions about the shape and size of test pieces and on plasticizer volatility, and discussion also took place on the speed of testing in dilatometric determinations and on the *Tm* curves for polystyrene, which become one continuous curve at equilibrium. Mr. Hollis, in reply to the last point, mentioned the investigations of Spencer and Boyer, and of Mark, which are not in agreement with those of Bekkedahl; he said that Mr. Millane and Mrs. Maclaren are shortly going to publish a paper which supports the first workers' contention that a straight-line graph is produced at equilibrium.

In a joint study of the "Interpretation of Mechanical Tests of Plastics", by C. G. Evans and H. W. Hall, the authors explained that they were concerned with the development of materials suitable for the production of aircraft structures. In particular, they referred to asbestos-reinforced phenolic resin compositions, moulded under very low pressures. They pointed out that the most important properties are strength and stiffness in tension, compression and shear, together with toughness, which is connected to some extent with impact strength. They explained the problem of translating laboratory tests into terms which will enable engineers to use the materials efficiently in practice. Mr. Hall stressed the difficulties associated with determinations of impact strength, and made a strong plea that tensile impact should replace existing methods, illustrating his remarks with information obtained from an American source. The work by the authors has involved examination of the effects caused by various reinforcing fillers with a variety of resins. The discussion on this paper covered a wide field, including the importance of moisture content in laminating material, the significance of good adhesion between filler and resin (and therefore the influence of type of asbestos on strengths, since different grades show varying adhesion), the size of test pieces and the influence of surface finish, the calculation of theoretical strengths of moulded compositions, the importance of rate of loading in testing, the possibility of developing improved sizes for glass fabrics with the idea of improving resin adhesion, the value of tensile-impact testing, and the influence of fibre length on ultimate strengths of mouldings.

The next speaker, Dr. E. A. W. Hoff, in a study of "Some Mechanical Properties of 'Perspex'", showed plainly how important is the fundamental approach of the first category mentioned by Dr. Megson. After considering the nature of polymer molecules, their entanglement and their mutual reactions, together with temperature effects, Dr. Hoff pointed out that it is unwise to take over existing metal-testing techniques with the expectation of obtaining results useful in the field of plastics. He illustrated his point by referring to the relations between molecular structure, on one hand, and fatigue results, compression and tensile testing and static loading strengths, on the other. Finally, in agreement with Mr. Hall, he emphasized the difficulty of interpreting satisfactorily the results of

conventional impact tests. Most of the comments on Dr. Hoff's paper dealt with fundamental ideas, although such practical matters as the value of impact tests were raised. There was general agreement with Dr. Hoff that it is not possible to apply metal tests to such heterogeneous materials as plastics. The mechanism of breaking was discussed, since it is not clear how molecules can become disentangled if viscous flow does not exist below the transition point. Dr. Hoff agreed there is evidence that carbon–carbon linkages are probably broken, although a mechanism involving the separation of bundles of molecules may also occur. Other topics brought up included: the production of a 'standard' scratch, the effect of plasticizer on stress/time curves, the 'memory' of test pieces after deformation (particularly in connexion with intermittent loading), and the 'weakest link' type of fracture. Finally, stress was laid on the importance of distribution curves in test work, and the necessity for keeping molecular mechanisms in mind when statistical analyses are being made.

"Two Extrusion Plastometers for use with Polyvinyl Chloride" was the subject of a paper by R. Hayes. Arising from the importance of 'flow' properties, he explained that two types of plastometer have been developed. The first consists essentially of a heated metal block containing a chamber from which plastic is forced by a known pressure through a weight-loaded lever. The time taken for extrusion of a standard volume of material is determined at various pressures, flow-time/pressure curves are drawn, and the pressure required to extrude material at a standard rate is taken as the index of flow. The second instrument is essentially a modification of the Atkinson and Nancarrow plastometer. The extrusion piston is driven down at constant speed, and develops a pressure which is recorded through a pressure capsule. Both instruments are empirical in character and were designed for development and factory control work.

In the final paper, on "Indentation Testing of Phenolic Mouldings by Brinell and Hot Needle Methods", by J. H. Bennitt and C. E. Avenell, Mr. Bennitt explained that the object was to explore the possibility of using indentation tests, which could be made quickly and accurately with minimum damage, as a means of checking properties of mouldings. The Brinell (cold ball) test has been found useful in determining compositions of mouldings and gross differences in curing. Chemical resistance can also be followed; for example, there is a direct relationship between absorption of sulphuric acid and change in depth of indentation. The hot-needle machine, originally developed by Bisterfeld and Stolting in Germany, gives similar correlations. Thus, depth of penetration is directly connected with degree of cure, resistance to chemicals and types of filler. Mr. Bennitt doubted whether the test is suitable for routine testing of degree of cure, but he gave various examples of its utility, for example, in showing that discoloration in mouldings had been caused by hot spots during moulding, and in following the rate of curing of silicone mouldings. This paper brought questions on the relation between indentation of mouldings and degree of water penetration, the influence of specimen thickness and the application of the hot-needle test to acid-resisting cements and to post-stoved mouldings.

Dr. D. J. van Wijk, of the Netherlands Plastics Research Institute of Delft, made an important contribution to the ensuing discussion. He criticized normal test methods on three scores: they bear little relation to the characteristic properties of plastics; time or speed of deformation are entirely neglected; and results of destructive tests are influenced by many unknown factors. The tests fail to provide a better understanding of the real elastic, visco-elastic and plastic properties because results cannot be expressed as ultimate physical constants. As examples, he pointed out that $E$ (modulus of elasticity) is not a constant but depends on temperature and time, and ageing-characteristics affect the results. He also mentioned the significant importance of relaxation times, and finally asked that more attention should be paid to creep and high-frequency vibration phenomena.

N. J. L. Megson

## CHEMICAL ENGINEERING AT THE CROSS-ROADS

In his presidential address entitled "Chemical Engineering at the Cross-Roads", delivered at the thirtieth annual corporate meeting of the Institution of Chemical Engineers, Sir Harold Hartley described chemical engineering as the fourth primary technology. He said that, just as the older technologies of civil, mechanical and electrical engineering developed when specialized knowledge increased, so the chemical engineer has evolved as a separate entity owing to the immense advances in the chemical and allied industries during the present century. The chemical engineer does not compete with engineers of the older classes, but works in harmony with them and supplements their knowledge. All engineers make use of practical experience based on scientific principles to solve the many problems which confront them; in the case of the chemical engineer, the directions in which he can apply his knowledge are so varied that it is becoming increasingly difficult to decide how he should be trained. It would seem, said Sir Harold, that even more emphasis than at present must be placed on the basic sciences and fundamental laws, so that a scientific rather than an empirical approach becomes natural, while flexibility of outlook and acquaintance with the methods of research are of vital importance. With such a background, technical details can be assimilated readily.

To illustrate the varied directions in which a chemical engineer may turn, Sir Harold quoted a few examples. One of the engineer's main tasks is the efficient use of energy; a modern steam power station depends largely upon the correct application of chemical engineering principles, while oil refining, with its most recent development the synthesis of chemicals, is a fast-expanding industry requiring chemical engineers by the hundred. Even more important will be the work of the chemical engineer when the 'fossil fuels' upon which we so largely depend for heat and power approach exhaustion. He is already attempting to produce atomic energy economically; to-morrow his task may be to utilize solar energy for controlled photosynthesis. In another direction he must devise means for extracting metals from ores of ever-diminishing richness, and in yet another he must endeavour to make increasing use of the so-called waste which arises during the pro-

cessing of natural materials. In agriculture the production of improved fertilizers, weed-killers, fungicides and insecticides, as well as antibiotics to eliminate disease in man and animals, is still in its infancy, and a vast new field awaits the large-scale application of biochemistry.

Amid so many possibilities, continued Sir Harold, only one thing seems certain—there are not nearly enough chemical engineers for the task, especially in Great Britain: for every chemical engineer now training in Britain there are more than twenty in the United States. It would be of some help if chemical engineering were included in the curriculum of every institution now teaching engineering of the older kind, but urgent action is required. If British industry is to maintain the lead won for it by its engineers in the past, a great and rapid increase in the number of chemical engineers must be regarded as one of the major needs of to-day.

## TECHNOLOGY AND THE HISTORY OF MAN

In his L. T. Hobhouse Memorial Trust Lecture at the London School of Economics and Political Science on October 23, 1951 (Pp. 19. London: Oxford University Press, 1952. 2*s.* net), Dr. Charles Singer, dealing with technology and history, said that it was largely through Hobhouse's influence that the view that the history of mankind should be considered as a whole and include all major human activities is now a commonplace among the English-speaking peoples. Nevertheless, Dr. Singer continued, despite the limitations of the idea of history that prevailed in the nineteenth century, efforts to integrate the records of the various manifestations of the human spirit can be traced back at least to L. Laurent's "Études sur l'Histoire de l'Humanité", which began to appear in 1855, to J. R. Green's "History of the English People" in the late seventies, and to H. D. Traill's "Social England", the last volume of which appeared in 1897. The United Nations Educational, Scientific and Cultural Organization is now engaged on the preparation of an integrated "Scientific and Cultural History of Mankind", some part of which might be expected about 1958.

One of the difficulties in this task, Dr. Singer pointed out, is that the time-curves of the rise and fall of the different forms of human activity do not always fit each other; and, for the history of technology in particular, the ordinary year-sequences cannot yield a useful framework. Division on a cultural basis appears to be more promising, and Dr. Singer suggested that for the history of technology the most convenient divisions are those made as follows: first, between the fishing and hunting stage (roughly, the Old Stone Age) and the agricultural stage (roughly, the New Stone Age); secondly, between the latter and the great social change which Prof. V. Gordon Childe has named the "Urban Revolution"; thirdly, between the latter and the discovery of gold and copper and the invention of writing; and fourthly, from this to the decline of the ancient empires about 500 B.C.

For the following period, until A.D. 1500, there is at present, said Dr. Singer, neither the knowledge nor the scholar to write an adequate history of Far Eastern technology, and in its place we can only substitute an account of the technology of the civilizations of the Mediterranean and the Near East and their medieval successors. The rise of experimental science in the period 1450–1650 gave the fifth great dividing line, and from the latter date self-conscious science began to determine the main direction of technology. There is no comprehensive survey of the history of technology, though for the mid-eighteenth century Diderot and his collaborators in the "Encyclopædia of the Sciences, Arts and Crafts" have provided more detailed and complete information than we have for any other. Dr. Singer concluded with a brief reference to the industry and contributions of C. Frémont and Dr. Henry Dickinson.

## BRITISH HYDROMECHANICS RESEARCH ASSOCIATION

### REPORT FOR 1951

At the annual general meeting of the British Hydromechanics Research Association, Viscount Waverley was re-elected president, and a council of eighteen elected with Dr. A. Ivanoff (Hayward-Tyler and Co., Ltd.) as chairman and Mr. H. N. G. Allen (W. H. Allen, Sons and Co., Ltd.) deputy chairman. Mr. G. A. Wauchope (Gwynne Pumps, Ltd.), the retiring chairman, was elected the first vice-president of the Association.

In the fourth annual report of the council, covering the period October 1950–September 1951*, reference is made to the completion of the Association's 14,000 sq. ft. laboratory and to the official opening, on May 24, 1951, by the president. The laboratory was the first industrial building to be erected in the new satellite town of Harlow, Essex. It consists of a large, mainly single-story, building. Sufficient experimental equipment has been installed and workshop facilities provided to enable the Association's staff to commence active research, in addition to maintaining the information and abstracting services to members of the Association. The two-story office block which adjoins the laboratory includes a library, drawing office, dark room and instrument laboratory.

The membership of the Association continues to increase, though somewhat slowly. A list of the ordinary and associate members is given in the annual report. It comprises forty manufacturing and user members, and forty-nine consultants and academic workers. The majority of the eligible companies in the pump industry are now members of the Association, but it is regrettable that, as yet, no financial support has been forthcoming from water-supply authorities, though they are among the principal users of much of the plant and machinery with which the Association is concerned. A grant is received from the Department of Scientific and Industrial Research, and close contact is maintained with the Fluid Mechanics Division of the Mechanical Engineering Research Organization at East Kilbride, Glasgow, and with university and independent research workers in hydraulics. The staff consists of the director of research, Mr. L. E. Prosser, a secretary, five research engineers, two research assistants and one draughtsman, in addition to library, office and workshop staff. It has been strengthened during the year under review by the recruitment of several junior staff.

* British Hydromechanics Research Association. Fourth Annual Report, October 1950 to September 1951. Pp. 28. (Harlow, Essex: the Association, 1951.)

Six research committees dealing with fundamental fluid mechanics, measurement and laboratory technique, centrifugal and allied pumps and turbines, control and motion of fluids in pipes and valves, seals and joints, and reciprocating machinery and displacement pumps and motors, respectively, assist the director of research in his work. The programme of research is large in view of the limited staff and financial resources of the Association, but it is being carried out actively and successfully. Details of several of the investigations in progress or recently completed are given in the annual report, and the results of some of these have been published as technical notes and in the journals of scientific societies. The various publications of the Association are listed in the report, and are in addition to the Association's *Bulletin*, in which appear translations and abstracts of papers on hydraulics and allied topics.

A development during the year has been the increasing demand for the Association to undertake special investigations for individual members on a cost payment basis, and five small investigations of this kind have been carried out. The most interesting of these, perhaps, is the one on the overflow spillway and outlet tunnel for a reservoir which is being constructed by the Weir Wood Water Board for the new town of Crawley. In connexion with this a 1/20 scale model of the Weir Wood scheme has been constructed at the Association's laboratory, the overflow spillway and outlet tunnel being made of transparent 'Perspex' so that the air entrainment and the flow at the entrance to the tunnel may be observed. An illustrated brief account of this together with that of other investigations has appeared recently in the April issue of *Water Power*.

## INTERNATIONAL STATISTICAL INSTITUTE

### CONFERENCES IN INDIA

THE twenty-seventh session of the International Statistical Institute, held in New Delhi during December 5–11, 1951, and in Calcutta during December 12–18, was the first occasion on which the Institute had met in India. The International Biometric Society, the International Econometrica Society, the International Association for Research in Income and Wealth, and the International Union for the Scientific Study of Population, which are affiliated organizations, also held joint or associated meetings with the Institute. In addition, a special session was convened of the International Statistical Association for Asia and the Far East. All these meetings combined together were called the "International Statistical Conferences: India 1951". The Indian Statistical Institute, Calcutta, acted as the host society.

Nearly a hundred and fifty statisticians from forty countries, other than India, participated in the conferences. Participants also included representatives of the United Nations Organization and several affiliated bodies. This was the first international conference in which the Peoples' Republic of China participated side by side with the United States.

Dr. Rajendra Prasad, President of the Republic of India, inaugurated the conferences. Shri C. D. Deshmukh, in his capacity as the Finance Minister, chairman of the Executive Committee and president of the Indian Statistical Institute, gave a review of the progress of statistics in India. After this the Prime Minister, Shri Jawaharlal Nehru, addressed the delegates and remarked that he was glad to notice a tendency among statisticians to deal more and more with the human aspects of a problem. Dr. S. A. Rice, president of the International Statistical Institute, then gave his address and very aptly termed the twenty-seventh session "the session of fulfilling". Prof. P. C. Mahalanobis presided.

Several meetings were held in the form of 'round table' discussions, which centred on the development of national statistical systems relating to population, agriculture and labour problems in the participating countries. These were followed by discussions on the concept of national wealth and income, estimation of national production in under-developed countries and related statistical problems, biometry and statistical sampling. The accuracy of demographical data, including the accuracy of censuses and the problem of quality in census data, problems of industrial statistics and statistical control of industrial products were also discussed.

Many excursions were arranged, including an air trip to Jaipur, and a special train took the delegates from Delhi to Calcutta with special halts at Agra and Benares. At the Indian Statistical Institute in Calcutta the delegates had the opportunity of studying the working of the National Sample Survey Project of the Government of India; and a trip to Nahazari, a sample village near Calcutta, provided the visitors with a first-hand opportunity of seeing village maps and their uses, plot identification, acreage survey work, the development of crop-cutting techniques, distribution of sampled households, etc.

The Calcutta session of the conferences was followed by statistical seminars during December 19–22, 1951; and lectures were delivered by well-known statisticians on population and vital statistics, labour statistics, national income and theoretical statistics. In addition, the United Nations Sub-Commission on Statistical Sampling held its fifth session in Calcutta during December 19, 1951–January 2, 1952. At the first meeting of the session, Prof. P. C. Mahalanobis was elected chairman for the fifth time. Many subjects of special interest were discussed in the session, among which may be mentioned: the use of survey and experimental techniques for the development of agriculture and small-scale (household and cottage) industries, especially in under-developed countries; sample surveys of current interest; use of sampling techniques for the improvement of statistics on acreage yield and forecast; statistical techniques for the development of methods for the testing of standards for countries entering into international trade; statistical technique in industry as a national resource; sample surveys carried out by the Indian Statistical Institute; sampling in population censuses; report on sampling to obtain road statistics; sampling of administrative forms, etc.

These international conferences in New Delhi and Calcutta were a reminder of Indian contributions to, and applications of, the science of statistics. The very facts that the United Nations Sub-Commission met in India, and that Prof. P. C. Mahalanobis has been serving as the elected chairman for five consecutive sessions, are but two facets of the recognition by the world at large of India's contributions to the science of statistical sampling.

H. HOME

# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## Structure of the Synthetic Polypeptide Poly-γ-methyl-L-glutamate

We have made a check on the assignment of the α-helix with eighteen residues in five turns to poly-γ-methyl-L-glutamate[1] by preparing and interpreting X-ray photographs of a sample of the material. The results obtained not only support the assignment, but also indicate that the β-carbon atoms are in position 2 rather than in position 1[2]. This is the same assignment of the β-carbon atoms as that made by Riley and Arndt[3] for serum albumin, on the basis of their determination of the radial distribution function.

X-ray photographs were prepared of oriented fibres of the synthetic polypeptide, with use of copper $K$ radiation, in cylindrical cameras, with radius 3 cm. or 10 cm., the fibre axis of the specimen being either parallel with that of the camera, or perpendicular to it and at various angles with the incident X-ray beam. The polypeptide was kindly provided by Prof. Carl Niemann; it had been synthesized, under his supervision, by Dr. R. E. Cline. Fibres were made from a solution of the amorphous polypeptide in dimethyl formamide.

The dimensions found for the hexagonal unit cell are $a = 11{\cdot}58$ A. and $c = 26{\cdot}33$ A. We believe these values to be reliable to within 1 per cent. The corresponding calculated value of the density is 1·40 gm.cm.$^{-3}$, with an uncertainty of $\pm$ 0·04. This value is a reasonable one, in comparison with the directly measured value, 1·31 gm.cm.$^{-3}$, in view of the fact that the directly measured values of density of polymers are usually 5–10 per cent lower than the X-ray values. This agreement eliminates the difficulty pointed out by Bamford, Brown, Elliott, Hanby and Trotter[4], who reported that their measurements of the X-ray photographs gave the dimensions $a =$ 11·95 A. and $c = 27{\cdot}0$ A., which lead to the low value 1·283 gm.cm.$^{-3}$ for the density.

Bamford, Brown, Elliott, Hanby and Trotter have also stated that the observed difference in infra-red dichroism for the NH and CO stretching modes of vibration indicates that the transition moment of the CO vibration makes an appreciably greater angle with the chain axis than does that of the NH vibration, and that this fact is difficult to interpret in terms of the α-helix composed of planar amide groups. We think that it is not unlikely that the direction of the effective electric moment vector for one or both of these vibrations deviates significantly from the internuclear direction, and that the difference in dichroism results from this effect.

The striking agreement in the distribution of intensities among twenty-eight layer lines of the fibre diagram of poly-γ-methyl-L-glutamate and the intensities indicated by the first terms in the Bessel-function expansion for helical structures with eighteen residues in five turns has been pointed out by Cochran and Crick[5] and by Bamford, Brown, Elliott, Hanby and Trotter[4]. We have obtained some additional evidence that the helical configuration is the α-helix of planar amide groups previously described[1]. The observed intensities of equatorial reflexions agree well with those calculated by averaging the atomic positions over a cylindrical surface[1]; we have now verified that the calculated intensity function ob-

Calculated intensities of fifth layer line reflexions for the 3·6-residue helix: the thin line gives the calculated intensities for the four main-chain atoms and the β-carbon atom in position 1, and the thick line those for the main-chain atoms and the β-carbon in position 2. The vertical lines represent the visually estimated intensities of the 10·5, 11·5 and 20·5 reflexions; their relative values are 43, 27 and 8 respectively

tained in this way does not differ appreciably from that for the α-helix in any orientation, the change in the form factor with change in azimuthal orientation of the α-helix relative to the axes of the unit cell being very small—less than 5 per cent. Moreover, the calculated intensity for the α-helix, oriented with an α-carbon atom on the line connecting the centre of one helix with the centre of an adjacent helix, is found to agree well with the observed intensities for the three reflexions in the fifth layer line, 10·5, 11·5 and 20·5 (strong, medium and weak, respectively), when the β-carbon atoms are included in the calculation, and are placed in position 2 ($z$ co-ordinate $-0{\cdot}76$ in Table 2 given by Pauling and Corey[2]) rather than in position 1. This comparison is shown in the accompanying graph. It seems not unlikely, then, that position 2 is correct for this synthetic polypeptide, and the fact that the same position has been assigned to the β-carbon atom in serum albumin by Riley and Arndt[3] suggests that this sense of the α-helix, relative to the configuration of the amino-acids, may be favoured by polypeptides and proteins generally.

We may point out that, in addition to the distribution of intensities in the layer lines, direct measurement of meridional spacings for this synthetic polypeptide supports the 18-residue 5-turn α-helix. Our measurement of the spacing of the identity distance from the second, third, fifth and eighth layer lines is 26·33 A., and our measurement of the spacing of the Perutz reflexion, representing the axial length per residue, is 1·472 A. The ratio of these, 17·9, is close to the value 18 required by hexagonal symmetry.

Harry L. Yakel, Jun.
Linus Pauling
Robert B. Corey

Gates and Crellin Laboratories of Chemistry,
California Institute of Technology,
Pasadena 4, Calif. April 4.

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## Composition of Silk

It is well known that the sericin component of silk is soluble in water, and the fibroin is soluble in certain acids and a variety of salt solutions. The latter can be dialysed to leave a solution of fibroin in water[1,2], from which water-soluble films can be cast. Ambrose *et al.*[1] have shown by infra-red methods that these are in the α-configuration, and that, on denaturation by alcohol or ammonium sulphate or by stretching, an incomplete conversion to the insoluble β-form occurs.

Earlier X-ray studies (Meyer)[3] showed the crystalline part of the fibroin structure to be made up of extended β-chains, with side-chains roughly alternately —H and —$CH_3$, that is, a copolymer repeat of alanine and glycine as in Fig. 1. The larger residues of the polypeptide, such as tyrosine, were associated with the non-crystalline parts of the fibre.

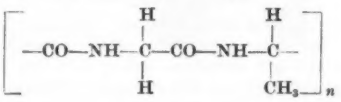

Fig. 1

From a survey of published equatorial spacings of X-ray diagrams of silk, it is suggested that this structure may apply only to part of the β-phase. In this the 'alanine/glycine' component of the crystal structure may be very similar to that of nylon[4], poly-L-alanine, or polyglycine with reference to the hydrogen-bonding distances. Fig. 2 shows a possible cross-section of the unit cell (or its sub-multiple) of this phase based on that assigned to polyglycine by Astbury[5]. The second component gives essentially the normal type of photograph of a β-structure with large side-chains. The 4·65 A. spacing is the 'backbone' hydrogen-bonding distance and that of ~9 A. the side-chain spacing. This structure would be associated with the tyrosine groups, etc., and from chemical evidence it appears likely that these larger groups tend to be associated together in discrete parts of the fibre[6].

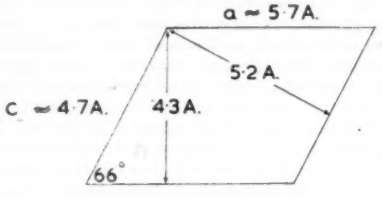


Fig. 2

The latest available analysis gives the serine content of fibroin as about 15 per cent[2], in contradistinction to 1·5 per cent as used by Meyer and Mark[3]. It is important, therefore, to consider the possible location of these residues in the fibroin chain with particular reference to their hydrophilic character. Previously, various examples of the isomorphic replacement of groups in fibrous lattices have been found[7]. In particular, Bunn[8] has demonstrated this in the case of hydrogen and the hydroxyl group in polyvinyl alcohol. It is suggested, therefore, that the —$CH_2OH$ group of serine may replace —$CH_3$ of alanine in the molecular chain of Fig. 1, and produce little change in the characteristic monoclinic β-lattice of the fibroin (Fig. 2). Chemical evidence[9] seems to support the presence of the serine residue in the glycine–alanine parts of the fibroin, although some of the 15 per cent of serine is also contained in the larger residues of the chain, for example, in the orthorhombic β-lattice. Polyglycine and poly-L-alanine are insoluble in water, but the presence of serine confers solubility on the portion of the chain containing the residues of low molecular weight; thus it is likely that the whole fibroin molecule is in the α-form in solution in the sac of the silkworm. Further, the fibroin and sericin are in solution together at approximately 30 per cent concentration[10], and Imms[11] describes the production of filament silk as follows: "The silk is secreted in the form of a filament composed of fibroin which is coated with a glutinous substance, sericin, formed by the transformation of the outer layer of the fibroin when the latter is oxidized and combined with water molecules". In the sac, the fibroin and sericin are probably similar polypeptides containing varying proportions of hydrophilic side-chains, with no clear-cut division between the two, but rather a gradation of solubility. The hydrophilic serine and threonine account for 45 per cent of the amino-acids in sericin, and this being more soluble probably retards precipitation of the fibroin.

A possible method of spinning employed by the silkworm would be: (*a*) alignment of the α-chains by extrusion and drawing; (*b*) extension of the less-soluble α-chains, that is, those containing mainly alanine/glycine/serine, into the monoclinic β-form; (*c*) partial transformation of other more stable parts of the chains into the orthorhombic β-form; (*d*) the retention around the fibroin of the more hydrophilic molecules in solution, forming the sericin fraction of the raw cocoon silk.

This explains the existence of sericin on the surface of the fibres as a consequence of the process of extrusion and coagulation, without the necessity of invoking oxidative processes.

This method of fibre formation differs from those of the rayon industry, where the filament is coagulated from the surface inwards whatever the mode of spinning; but it explains why such a highly orientated and flexible structure is obtained in these natural filaments. Further, it suggests that earlier regenerated fibroin filaments were brittle and difficult to orientate after coagulation[2] because sericin is essential to the spinning process as carried out by the silkworm.

A more detailed study of the mechanism is being made. We are indebted to Mr. C. Willoughby, of the Department of Biology of this College, for his assistance.

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## Energetics of Peptide Formation

High-molecular polypeptides containing only one kind of amino-acid are prepared by polymerization of N-carboxylic-α-amino-acid anhydrides[1] (α-amino-acid-NCA). The determination of the heat of combustion of these compounds and of the corresponding amino-acids offers for the first time the possibility of estimating quantitatively the energetics of formation of high-molecular peptide.

Bomb calorimetric measurements were carried out with *d,l*-phenylalanine and sarcosine derivatives. The heats of combustion (cal./gm.) and combustion enthalpies (kcal./mole) of these compounds are given in Table 1.

Table 1. Heats of Combustion and Combustion Enthalpies

| Compound | Heat of combustion (cal./gm.) | Combustion enthalpy (kcal./mole) |
|---|---|---|
| *d,l*-Phenylalanine | 6,727·5 | −1,112·3 |
| *d,l*-Phenylalanine-N-carboxylic acid anhydride | 5,835·8 | −1,116·1 |
| *d,l*-Phenylalanine polypeptide, benzene soluble | 7,503·2 | −1,105·2 |
| *d,l*-Phenylalanine polypeptide, benzene insoluble | 7,479·1 | −1,101·7 |
| Sarcosine | 4,484·3 | − 400·0 |
| Sarcosine-N-carboxylic acid anhydride | 3,509·6 | − 403·8 |
| Sarcosine polypeptide | 5,626·1 | − 400·3 |

Molar combustion enthalpies of polypeptides are expressed in terms of chain units neglecting the end-groups. From the combustion enthalpies as given in Table 1, reaction enthalpies were calculated and are shown in Table 2.

Table 2. Reaction Enthalpies

| Reaction | Reaction enthalpy (kcal./mole) |
|---|---|
| Phenylalanine-N-carboxylic acid anhydride (s) → polypeptide, benzene soluble (s) + carbon dioxide (g) | −10·9 |
| Polypeptide, benzene soluble (s) → polypeptide, benzene insoluble (s) | − 3·5 |
| Phenylalanine (s) → polypeptide, benzene soluble (s) + water (l) | − 7·1 |
| Sarcosine-N-carboxylic acid anhydride (s) → polypeptide (s) + carbon dioxide (g) | − 3·5 |
| Sarcosine (s) → polypeptide (s) + water (l) | + 0·3 |

The formation of high-molecular polypeptides by polymerization of N-carboxylic acid anhydrides is an exothermic reaction as expected. The transformation of the benzene-soluble form of phenylalanine polypeptide into the insoluble one is also exothermic.

Also given in Table 2 is the reaction enthalpy for the hypothetical condensation of the amino-acids to the corresponding polypeptides. With phenylalanine, this hypothetical reaction is exothermic, whereas with sarcosine it is nearly athermic. The last two results are in striking contrast with the hitherto known endothermic reactions of glycine yielding glycylglycine, diglycylglycine and triglycylglycine, and glycine and leucine yielding glycylleucine[2]. The substitution of one hydrogen atom in the $CH_2$- or $NH_2$-group of glycine by different groups obviously has an important influence on the energetics of peptide formation.

It therefore seems likely that, in energetically favourable cases, the condensation of amino-acids will be spontaneous; in other words, it will not need to be coupled with another energy-producing process.

A full account of this investigation will be published in the near future in *Monatshefte für Chemie*.

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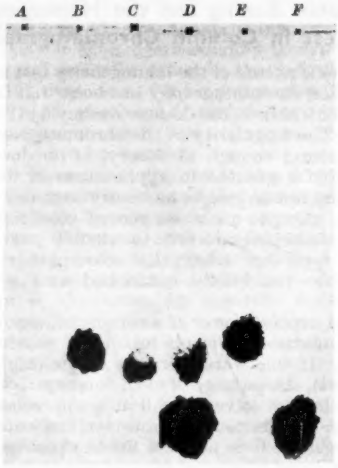
## A New Method for the Detection of Peptides and Similar Compounds on Paper Chromatograms

Since the first introduction[1] of paper chromatography for the separation and identification of amino-acids and peptides, ninhydrin has been used almost exclusively as the spraying reagent to reveal the positions of the spots, although some use has been made of ultra-violet fluorescence[2] and of spraying with potassium permanganate[3] and specific reagents for individual amino-acids[4]. Ninhydrin, however, has two serious limitations: it does not react with cyclic peptides or with acylated amino-acids or peptides, while with peptides, since only the terminal amino-group enters into the reaction, the colour developed with a given amount of material decreases with increasing molecular weight.

We have found that peptides of all kinds, including proteins, diketopiperazine and acylated amino-acids and peptides, can be very easily detected by chlorination and subsequent spraying with starch–potassium iodide, the colour being, of course, due to the liberation of iodine by the N-chloro-peptide formed in the chlorination stage:

$$\text{—CO—NH—} \xrightarrow{Cl_2} \text{—CO—NCl—} \xrightarrow{KI} \text{—CO—NH—} + KCl + \tfrac{1}{2}I_2.$$

The chromatogram is run and the solvent removed, as completely as possible, in the usual manner; thorough removal of the solvent is essential if an over-intense 'background' coloration is to be avoided, and it is generally desirable first to heat the paper to 60° for two hours and then to hang it in air overnight, followed by a final heating to 60° for 30 min. The paper is then loosely rolled and placed in an atmosphere of gaseous chlorine for 10 min., conveniently in a loosely corked, dry gas-jar. The paper is then removed and hung in a current of air at room temperature for 30 min. or until a trial portion shows little or no 'background' on spraying with the starch–iodide reagent. The chromatogram is finally sprayed lightly and evenly with 1 per cent starch – 1 per cent potassium iodide solution. The compounds are at once clearly revealed as intense blue-black spots on a faint blue background; the spots fade to brown in the course of a few hours and fade completely in a few days; they should, therefore, be marked or photographed as soon as possible after the final spraying. There is no advantage in replacing the starch by sodium starch glycollate[5] or polyvinyl alcohol[6]. If desired, the chlorine–starch–iodide procedure can be applied successfully to papers which have already been sprayed with ninhydrin.




(*A*) and (*F*), Diketopiperazine; (*B*) and (*E*), triglycyl-glycine ethyl ester; (*C*) and (*D*), product of heating glycyl-glycine ethyl ester. The left-hand half of the paper (*A*—*C*) was sprayed with ninhydrin–butanol, and the right-hand half (*D*—*F*) treated with gaseous chlorine and then sprayed with starch–iodide. The chromatogram was developed with butanol/pyridine/water (65 : 35 : 65)

The accompanying photograph shows parallel chromatograms of the product of heating glycyl-glycine ester at 78° for 20 hr., diketopiperazine and triglycyl-glycine ethyl ester, run on the same paper and treated by both the new method and the normal ninhydrin procedure.

Using about 20 μgm. of material applied to filter paper in 5 μl. of water, excellent spots were given by a range of peptides (glycyl-glycine and its ethyl ester, diglycyl-glycine and its ethyl ester, triglycyl-glycine ethyl ester, tetraglycyl-glycine ethyl ester, pentaglycyl-glycine ethyl ester, poly-D-glutamic acid of molecular weight *c.* 30,000) and by equine and bovine serum albumins. The colour developed by the new method, unlike that obtained with ninhydrin, is as intense with proteins and peptides of high molecular weight as it is with those of low molecular weight. Comparative experiments to demonstrate this point were carried out in which 5-μl. drops of solutions of bovine serum albumin and glycine were applied to filter paper, giving 12-mm. diameter spots, dried off and the colour developed by the new method and by the usual ninhydrin method; the following minimum amounts for ready detectability were found in this way:

| | Chlorine–starch–Iodide | Ninhydrin |
|---|---|---|
| Glycine | 0·3 μgm. | 0·3 μgm. |
| Albumin | 0·5 „ | 40 „ |

The greater sensitivity of the new method for the detection of the protein is remarkable.

The new procedure also gives good spots with the cyclic peptide diketopiperazine and with acylamino-acids with at least one free hydrogen attached to the acylated nitrogen, including acetyl-amino-acids (for example, acetyl-glycine, acetyl-alanine, acetyl-leucine, N-acetyl-serine, acetyl-phenylalanine), benzoyl-amino-acids (for example, benzoyl-glycine and benzoyl-alanine) and carbobenzoxy-amino-acids (for example, carbobenzoxy-glycine, carbobenzoxy-phenylalanine, carbobenzoxy-glycyl-proline); as expected, phthalyl-glycine gave no spot, whereas phthalyl-glycyl-glycine gave a positive, although rather weak, reaction.

Most amino-acids (for example, glycine, alanine, leucine, serine, threonine, glutamic acid, lysine, phenylalanine, histidine and, weakly, proline) give positive results, presumably owing to formation of the N-chloro-amino-acid, ClNH.CH*R*.$CO_2$H; certain amino-acids (for example, cysteine, cystine, methionine, tyrosine) fail to react, probably owing to preferential chlorination or oxidation at some other point in the molecule.

For certain purposes, the new procedure has obvious advantages over the established ninhydrin method. In addition to its value for the detection of cyclic peptides, its great sensitivity should make it especially useful in work with peptides of high molecular weight and with proteins, for example, in micro-electrophoresis on paper, where Durrum[7] was apparently unable to apply the relatively insensitive ninhydrin reaction. It should also enable paper chromatography to be applied without difficulty to acylamino-acids, especially the acetyl and carbobenzoxy-derivatives, which are at present seldom, if ever, employed owing to the absence of a suitable spraying reagent. The method is clearly capable of extension to the detection on paper chromatograms of other types of compound containing chlorinatable nitrogen, such as amides, imides and primary and secondary amines, including purines and benzimin-azoles.

We are grateful to the Department of Scientific and Industrial Research for a maintenance allowance which has enabled one of us (P. W. G. S.) to take part in this work.

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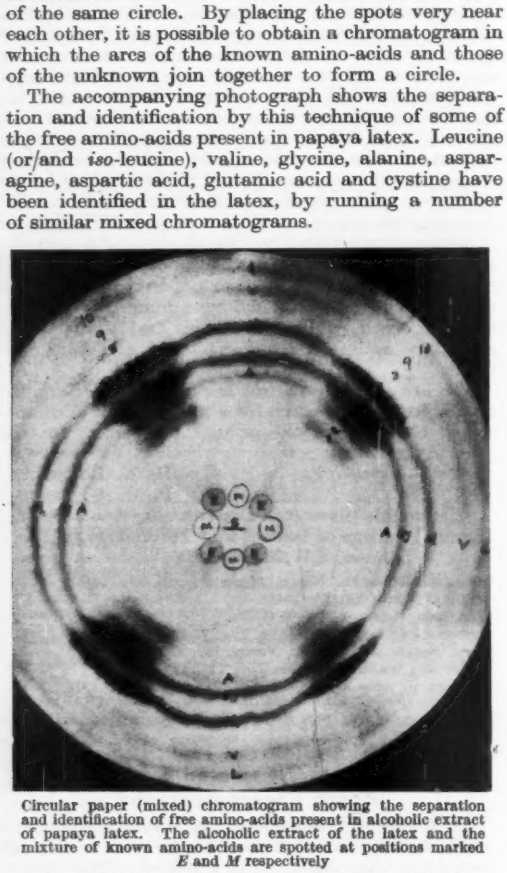
## A Technique for the Identification of Amino-Acids separated by Circular Paper Chromatography

In a recent publication[1] from this laboratory, a method for the separation of amino-acids by circular paper chromatography was outlined. The present communication describes a new technique, which permits the identification of amino-acids by reference to the chromatogram of the known amino-acids run on the same paper.

Briefly, the method consisted in spotting the solution containing the amino-acids on the circumference of a small circle of about 4 cm. diameter drawn with a pencil from the centre of a slit cut at the centre of Whatman No. 1 circular filter paper (18·5 cm. or 24 cm. in diameter). Some of the spots, usually the alternate ones, were of a mixture of known amino-acids and the others were of the unknown mixture. A strip of filter paper (0·5 cm. × 4 cm.), folded at the centre and inserted into the slit, served as a detachable 'tail' for irrigating the chromatogram

with the solvent. The filter paper with its 'tail' was then placed on a suitable support in such a way that the 'tail' was kept immersed in a developing solvent (*n*-butanol–acetic acid–water, 40 : 10 : 50) contained in a small beaker, and the whole was kept under a bell jar. As usual, the chromatogram was developed and the position of the amino-acids located by spraying with ninhydrin reagent (0·1 per cent in acetone). The position of amino-acids is indicated by the formation of well-defined coloured concentric arcs, the radius of each varying with the type of amino-acid. The amino-acids present in the unknown sample can be easily identified by reference to the arc of a known amino-acid formed on the circumference of the same circle. By placing the spots very near each other, it is possible to obtain a chromatogram in which the arcs of the known amino-acids and those of the unknown join together to form a circle.

The accompanying photograph shows the separation and identification by this technique of some of the free amino-acids present in papaya latex. Leucine (or/and *iso*-leucine), valine, glycine, alanine, asparagine, aspartic acid, glutamic acid and cystine have been identified in the latex, by running a number of similar mixed chromatograms.



Circular paper (mixed) chromatogram showing the separation and identification of free amino-acids present in alcoholic extract of papaya latex. The alcoholic extract of the latex and the mixture of known amino-acids are spotted at positions marked *E* and *M* respectively

*A*, Asparagine; *Gy*, glycine; *Al*, alanine; *V*, valine; *L*, leucine; *S*, slit. Developing solvent, *n*-butanol – acetic acid – water (40 : 10 : 50)

This technique is now in continuous use in this laboratory in the study of the amino-acid metabolism in plants, animal tissues and biological fluids. Full details will be published in the *Journal of the Indian Institute of Science*.

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## Double Zoning and the Homogeneity Test in Column Chromatography

The fickle nature of the homogeneity test as applied to partition chromatography has been well illustrated in a recent article on double zoning by Dr. Lester Smith[1]. The singularity of the chromatographic zone, though sound enough in theory, is no doubt taken too much for granted in applications in which conditions are not so simple as theory assumes. It seems relevant, now, to place on record conditions which I have found conducive to double zoning of a similar type on adsorption chromatograms, and which were too briefly mentioned at a symposium in 1946 [2].

The adsorptive power of a column of, say, silica gel/'Celite' mixture[3] depends upon its residual water content. If this water content is low (highly active adsorbent), the passage of even comparatively powerful developing solvents will not appreciably affect the water distribution. If, however, the water content is appreciable, it is possible for the passage of ethyl ether to cause partial elution of the water from the upper portion of the column, while a weak developer like light petroleum would still be ineffective in this way.

If the passage of ether is stopped well before the excess water is completely removed from the column, there will remain an intermediate wet zone of very low activity reminiscent of the wet film of Dr. Lester Smith. Further washing with light petroleum will remove the ether without affecting appreciably the position of the wet zone. This effect has been followed with columns in which the silica gel has been impregnated with cobalt chloride before activation.

Materials chromatographed on columns prepared in this way appear to split into two zones on reaching the deactivated section, eventually to reunite in a more diffuse zone lower down. However, in some cases the effect has appeared to be more lasting, and the conditions favouring this seem to be the use of a binary developer (for example, petroleum/ether), which in due course can cause further development of the wet zone at a rate comparable with that of the double zones of the adsorbate.

Dr. Schroeder[4] has noted the double-zone effect with many homogeneous compounds chromatographed on a similar adsorbent. It may be significant that the prewashing procedures described by Dr. Schroeder all employ first a solvent of strong developing power and finish with a wash of light petroleum.

To summarize, it appears that double zoning on adsorption chromatograms may occur when the column is treated with a weakly developing solvent following earlier treatment with a more strongly developing solvent, either in a pre-washing procedure or, presumably, during actual development of the chromatogram.

It is as well to mention that the homogeneity test is beset by other similar pitfalls. There are many recorded examples of adsorbates undergoing chemical change during chromatography, particularly on alumina. In my own experience, the separation of a second yellow zone, while chromatographing a mixture of 4-nitro-N : N-diethylaniline with a compound suspected of being identical, nearly led to a false conclusion. The second zone contained transformation products of the substance, formed by contact with the alumina, and on repetition with silica gel/'Celite' no secondary zone was formed.

Even though an adsorbent may be inactive itself in promoting chemical change, secondary transformation zones may still arise, for example, through the action of light or by oxidation. Striking examples of double zoning due to the photosensitivity of compounds such as 2 : 3-benzanthracene[5] and N-nitroso-4-nitro-N-ethylaniline[6] have been noted.

It is well known that the result of a single homogeneity test is inconclusive, and that the development of one zone should be confirmed by a change of solvent or adsorbent. However, even the formation of two zones does not necessarily indicate initial heterogeneity, and it is evidently advisable to determine the nature of the zones by separate elution and rechromatography.

When testing the identity of two substances by 'mixed chromatography', it is usual to mix them together and apply the homogeneity test. For some years now it has been the practice in this laboratory to run two identical chromatograms side by side, one for each substance, so that the significance of any secondary zones would be apparent. This procedure, introduced by Dr. C. A. Parker, also allows detailed comparison of the appearance of the two zones, a feature which is lost on the usual 'mixed chromatogram' and which may allow immediate differentiation between two substances developed to the same distance.

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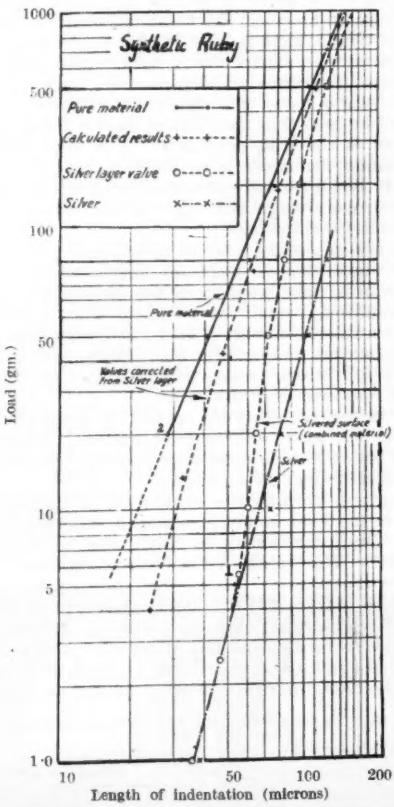
## 'Elastic' and 'Plastic' Hardness of Hard Materials

In the majority of the micro-hardness tests[1], the indenter has to be removed to measure the indentation, and this is also the case in designs where the indenter is mounted in the front lens of the microscope objective (Zeiss–Hanemann ; Cooke, Troughton and Simms). Therefore, all these instruments measure only the hardness after the load has been removed, that is, plastic hardness. With elongated indenters and partly with square-base pyramid indenters, it can be assumed that the recovery in the direction of the diagonal or longest diagonal is zero ; while this seems to be correct for large deformations, it has not yet been proved correct for very small deformations[2] on hard materials.

Some years ago it was suggested that in the case of hard materials pressed by a hard diamond indenter, where no plastic deformations could be observed, a thin evaporated silver film should be used to make the contact area visible. In preliminary tests there appeared to be no use for the information obtained, but subsequent tests have shown that this can be a very sensitive method for determining the 'elastic' hardness. A thin evaporated silver layer of about 0·1 micron thickness, while fully adhering to the matrix surface, forms a brittle coat. Once disturbed by a contact pressure, it cannot recover and remains torn. Thus microscopic inspection can reveal the area of contact when the maximum pressure has been exerted. Brodie and Smoluchowski[3], as well as Bergsman[4], used a thin coat on the diamond indenter to make the elastic deformation of the specimen visible ; but with this method it is only possible to perform one test before further coating. The method to be described permits a large number of indentations to be made, one after the other. (Recently, the coating technique was simplified by holding the surface against a flame and depositing a thin soot layer. In these instances no corrections have to be applied for the thickness of the layer.)

At present the following materials have been investigated with the new method : boron carbide, silicon carbide, synthetic corundum (ruby, see graph), and diamond (Brazil), all known as very hard materials. In each instance, the load-deformation characteristic was determined with a double-cone indenter[5] on (*a*) polished and cleaned surface, (*b*) on a polished silver surface (silver block), (*c*) polished surface coated with an evaporated silver film of about 0·1 micron thickness. When plotting the experimental values on a log–log diagram (Meyer analysis) the following result was found. With reference to the graph, the values obtained with surface (*a*) lay along a straight line ; below point 2 no indentation could be observed (using an oil-immersion objective on the Vickers projection microscope giving




Experimental results on synthetic ruby. (1) 'Breaking-off' point of composite material line from silver line (contact of indenter with base material). (2) Limit of observation with available optical means

about 2,200 × magnification). With surface (*a*) at relatively small loads (less than 5 gm.) small visible indentations could be observed, which were equivalent to the values obtained with a polished massive silver block (*b*). After being equivalent to silver, the load-deformation curve of (*c*) changed its direction and with a steep incline nearly joins the line *a* (pure material) and then runs parallel to it.

This leads to the following conclusions. The section of the combined material curve *c* below 1, in spite of the fact that it was obtained on a hard material, reflects certainly only the behaviour of the silver; thus 1 is the point at which contact was made with the underlying surface: after this the indentations should become visible on the pure material beneath the silver. This, however, could not be confirmed with the optical means available.

The values obtained with the silvered surface include both 'elastic' and 'plastic' deformations. Actual indentation, whether 'elastic' or 'plastic', does not begin until the silver layer has been completely pierced (point 1).

As the load is increased, part of it will be available for indenting the pure base material, hence a correction has to be made for the load taken up by the silver layer. Similarly, the silver layer has a definite thickness, and correction has to be made for this as the deformation under the layer is smaller than observed.

Instead of a curve *c*, a new corrected curve *d* can be drawn showing the total deformation of the material tested, that is, plastic plus elastic deformation. As curve *a* shows plastic deformation only, the horizontal difference in deformation between the curves *d* and *a* shows the 'elastic' deformation.

It will be seen that the relative elastic deformation increases as the load decreases. If it were possible to continue the curve *a* to lower values, it would probably reach a zero indentation with a finite load, in which case further reduction in load would cause purely elastic deformation.

*Analysis of results.* If, as mentioned previously, 'plastic' indentations were no longer visible, then the hardness, calculated from the conventional load area definition, would be infinite. This imaginary condition can be assumed to be approachable with blunt indenters and small loads. Taking the 'elastic' deformation into account, however, this concept of infinite hardness does not arise.

The values obtained by correction gradually run closer to the curve of the pure material, which indicates the reduction of relative elasticity and finally the practical end of elasticity.

The graph permits the evaluation of hardness $h$, which is the load in gm., causing a deformation of $l = 0{\cdot}1$ mm., for example, with the double-cone indenter[6]. The values $h$ for both plastic and total deformation (plastic + elastic) are shown in the table. Silicon carbide (0001) appears to have no elastic or recoverable hardness, whereas no plastic deformation could be measured on the diamond surface. The combined plastic and elastic hardness of diamond is certainly more than double that of boron carbide.

Values of Hardness $h$ for the Materials Tested
$h$ in gm. for $l = 0{\cdot}1$ mm.

| Substance | Plastic | Plastic and elastic |
|---|---|---|
| Synthetic ruby | 420 | 350 |
| Silicon carbide | 420 | 420 |
| Boron carbide | 680 | 500 |
| Diamond | — | 1,170 |

The hardness test has frequently been compared with tensile tests and many attempts have been made to correlate them. The new method of determination may give some new help in this direction, as it allows differentiation between 'elastic' and 'plastic' hardness ranges.

I am indebted to Prof. S. Tolansky for silvering the specimens and for advice in discussing the results, and to Mr. F. M. H. Priestland for making the tests.

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## A New Theorem in the Classical Theory of Elasticity

We have found that the solutions of all problems concerning the equilibrium of isotropic solids in the classical theory of elasticity may be simply transformed so as to yield solutions to corresponding problems for certain anisotropic solids.

Anisotropic solids which possess an axis of elastic symmetry ('transversely isotropic' solids) have five independent elastic constants; using Love's notation[1], we take these to be the coefficients $c_{11}$, $c_{12}$, $c_{13}$, $c_{33}$, $c_{44}$, in the strain-energy function when the $z$-azis of rectangular Cartesian co-ordinates is parallel to the symmetry axis. Here we consider the case in which these elastic constants satisfy two conditions:

$$\frac{c_{13}}{c_{12}} = 2\,\frac{c_{44}}{c_{11} - c_{12}} = \left(\frac{c_{33}}{c_{11}}\right)^{1/2} \equiv \nu \text{ (say)}. \quad (1)$$

We have, therefore, only three independent constants, which may conveniently be taken to be $c_{11}$, $c_{12}$ and $\nu$.

These conditions, which are additional to those of transverse isotropy, are chosen for reasons of mathematical simplicity; it has yet to be determined whether they are satisfied by any actual materials. Their physical significance is perhaps more readily understood when they are expressed in the equivalent form

$$\frac{\sigma_{xy}}{\sigma_{xz}} = \frac{\mu_y}{\mu_z} = \left(\frac{E_z}{E_x}\right)^{1/2} \equiv \nu. \quad (2)$$

Here, $\sigma_{xy}$ and $\sigma_{xz}$ are Poisson's ratios for a tensile stress in the direction $0x$; $\sigma_{xy}$ is the ratio of the contraction in the direction $0y$ and the extension in the direction $0x$, and $\sigma_{xz}$ is the ratio of the contraction in the direction $0z$ and the extension in the direction $0x$; $\mu_y$ is the shear modulus for a shear in which planes perpendicular to $0x$ are displaced in the direction $0z$; $\mu_z$ is the shear modulus for a shear in which planes perpendicular to $0x$ are displaced in the direction $0y$; $E_x$ and $E_z$ are Young's moduli for tensile stresses in the directions $0x$ and $0z$. It can be seen that $\nu$ is a measure of the degree of anisotropy, $\nu = 1$ being the condition for isotropy.

We introduce new dependent and independent variables, $(u', v', w')$ and $(x', y', z')$, which are related to the displacement components $(u, v, w)$ and the Cartesian co-ordinates $(x, y, z)$ by the equations

$$u' = u,\ v' = v,\ w' = \nu^{1/2} w,$$
$$x' = x,\ y' = y,\ z' = \nu^{-1/2} z. \quad (3)$$

We then express all the basic equations and quantities of the classical theory of elastic equilibrium in terms of the new variables. Corresponding to the infinitesimal strain components $e_{xx} = \partial u/\partial x$, $e_{yz} = \partial v/\partial z + \partial w/\partial y$, etc., we define the quantities $e'_{xx} = \partial u'/\partial x'$, $e'_{yz} = \partial v'/\partial z' + \partial w'/\partial y'$, etc.; corresponding to the stress components $p_{xx} = \partial W/\partial e_{xx}$, etc., where $W$ is the strain-energy function, we define the quantities $p'_{xx} = \partial W/\partial e'_{xx}$, etc.; and in place of the components $(X, Y, Z)$ of the body forces per unit mass we write $(X', Y', Z')$, where

$$X' = X,\ Y' = Y,\ Z' = \nu^{-1/2} Z. \quad (4)$$

Finally, we express the strain-energy function, stress-strain relations, stress-equations of equilibrium, and compatibility conditions, in terms of the new variables. We then find that these all have the same form as the corresponding equations, expressed in terms of the old variables, for an isotropic solid with the same elastic constants, $c_{11}$, $c_{12}$. This proves the result stated above.

It is clear that the method may be applied to problems involving more than one set of values for the elastic constants $c_{11}$ and $c_{12}$, since these are not affected by the change of variables; but the value of the elastic constant $\nu$ and the direction of elastic symmetry must be the same everywhere.

The actual method of deriving one solution from another is to express the conditions of the problem and its solution for the isotropic case in terms of the old variables, and then to replace the variables

$$z, w, e_{yz}, e_{zz}, e_{zz}, p_{yz}, p_{zx}, p_{zz}, Z,$$

wherever they occur, by

$$\nu^{-1/2}z,\ \nu^{1/2}w,\ \nu^{1/2}e_{yz},\ \nu^{1/2}e_{zx},\ \nu e_{zz},\ \nu^{-1/2}p_{yz},\ \nu^{-1/2}p_{zx},\ \nu^{-1}p_{zz},\ \nu^{-1/2}Z.$$

This yields the solution in terms of the old variables to a corresponding problem for the anisotropic case.

I am indebted to the Council and Director of Research of the British Rayon Research Association for permission to publish these results.

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## Holes in Crystals

The screw dislocation mechanism of crystal growth proposed by Frank[1] has been verified by the observation of growth spirals on faces of beryl[2] and silicon carbide[3]. In particular, the recent work of Verma[3] provides very satisfactorily a confirmation of many of the theoretical predictions.

As additional evidence for this mechanism, we wish to report an unusual phenomenon concerning the development of holes in crystals of $AlB_2$, which seems comprehensible only on the basis of a crystal grown by a screw dislocation. That screw dislocations may have been present in these crystals is indicated by the observation of spiral growth patterns on other $AlB_2$ crystals prior to the development of the holes.

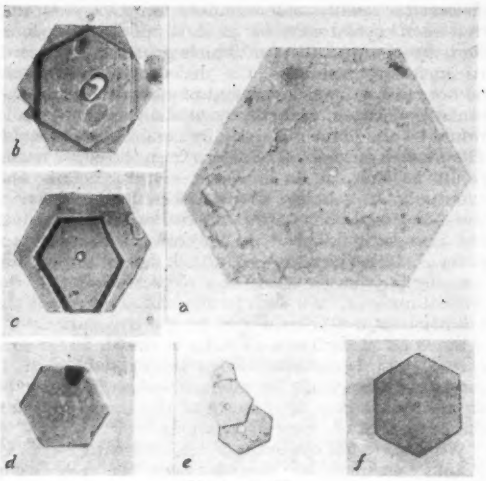


Fig. 1. × 360

The initial (and repeatable) observation was that in a preparation containing several thousand single crystals of $AlB_2$, almost every crystal had small round holes in it. The crystals were thin hexagonal plates (several tenths of a millimetre across) and usually there was only one round hole (1–20 $\mu$ in diameter) near the centre of a plate. Photomicrographs of representative crystals are shown in Fig. 1. Multiple holes usually occurred for twinned crystals, but occasionally could be found in a single crystal. The remarkable roundness of the holes is shown strikingly by an electron micrograph, Fig. 2.

The crystals originally were firmly embedded in a matrix of aluminium, which was removed by solution in hydrochloric acid. Presumably the acid also attacked the $AlB_2$ crystals, but at their centres only. This was verified by observing with a microscope the process of hole formation in crystals that were obtained without visible holes. Such crystals would result from milder etchants for removing aluminium; for example, acetic acid, mercuric chloride, dilute hydrochloric acid, or an electrolytic etch.

Spiral growth patterns (Fig. 3) could be observed on these latter crystals. It was necessary, however, to give a slight etch in order to reveal clearly the spiral terraces, for which the step-heights were of the order of 200 A. It is possible that screw dislocations of much smaller step-heights were present in some crystals; but these could not be observed with our techniques.

The preferential attack by solvents at the centre of the crystal in the uniform manner that was

Fig. 2. × 11,000

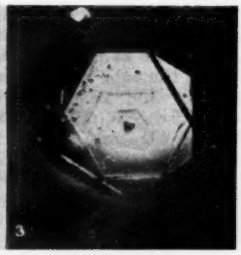


Fig. 3. × 180

observed is readily understandable on the assumption that each crystal contains at least one screw dislocation, by the operation of which growth took place. In such circumstances, the dislocation axis would be normal to the close-packed planes (00.1 face) and centrally located, and the tip of the growth-pyramid would be the point most readily attacked by solvent. The process of removal of atoms from the edges would result at first in an inverted conical hollow and eventually in a hole. The remarkable roundness of the hole, especially after extensive etching, does not necessarily depend on a screw dislocation property. Indeed, many of the holes observed are considerably larger than the expected size of the critical nucleus. We wish to emphasize only that the initiation of the holes occurs at the dislocation.

Since an etched hole in $AlB_2$ is shown to be connected with a screw dislocation originally, it is suggested that selective etching techniques may be an additional help to a study of the occurrence and the properties of screw dislocations.

We wish to acknowledge discussions with Dr. F. C. Frank, particularly during some of the early observations.

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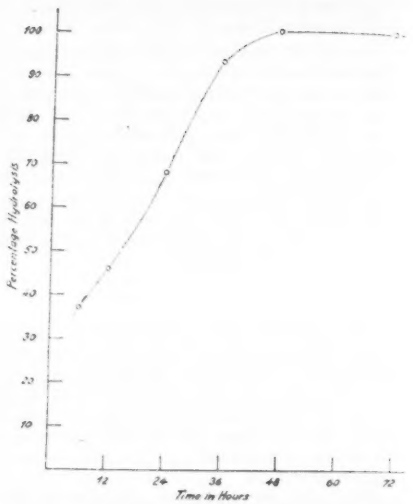
## Hydrolysis of Casein with Sulphur Dioxide

Acid hydrolysis of casein usually results in the complete destruction of tryptophane and the formation of large amounts of humin. White and Sayers[1] reported that casein could be hydrolysed with very dilute sulphuric acid without complete loss of tryptophane. Other workers have reported that reducing agents such as stannous chloride and titanous chloride prevent humin formation[2,3]. Rigby[4] claims that nascent hydrogen helps to prevent destruction of tryptophane during the hydrolysis of casein with sulphuric acid.

In the course of an investigation on the use of various acids for the hydrolysis of casein, we have carried out preliminary experiments with liquid sulphur dioxide. It seemed possible that the reducing properties of this material might prevent destruction of tryptophane. It was also hoped that the gas could be removed readily from the amino-acid solution by boiling or atomization, thus avoiding the laborious procedure of precipitating the hydrolytic agent as an insoluble salt.

Commercial casein (2 gm.), sulphur dioxide (12 gm.) and ice (50 gm.) were sealed in a 'Pyrex' Carius tube and heated at 100° C. At the end of the heating period, the tube was cooled, the contents completely removed and the hydrolysed material analysed for total nitrogen (micro-Kjeldahl) and amino-nitrogen (formol titration). The results are shown in the accompanying graph. The values which are given for percentage hydrolysis were obtained by dividing the ratio of amino-nitrogen to total nitrogen by a factor of 0·85.

The hydrolysates which we obtained in the 6-hr., 12-hr. and 24-hr. experiments were water clear and




gave a strongly positive Hopkins–Cole test for tryptophane. The 36-hr., 48-hr. and 72-hr. hydrolysates were pale red in colour and the Hopkins–Cole test was negative.

It is evident from these results (1) that sulphur dioxide is a rather effective agent for hydrolysing proteins if present in sufficient concentrations; and (2) that, for a given degree of hydrolysis, there is less destruction of tryptophane with sulphur dioxide than with sulphuric acid in the absence of reducing agents.

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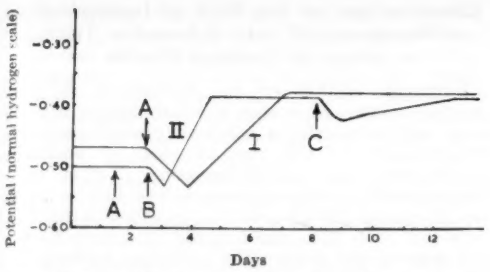
## Influence of Sulphate-reducing Bacteria on the Corrosion Potential of Iron

The potential assumed by an iron electrode immersed in a culture of sulphate-reducing bacteria has been studied by Hadley[1], using a heterotrophic medium. These experiments indicated that the inoculation of the sterile medium, in which the potential of an iron electrode had been allowed to reach a steady value, was followed by a movement of the potential in the anodic (negative) direction. This, in turn, was followed by a rise to a steady value more cathodic (positive) than the initial value in a sterile medium. These changes of potential are shown diagrammatically in the accompanying graph. We feel, however, unable to agree with the explanation given for the first fall of potential, namely, that it is due to bacterial utilization of hydrogen with consequent depolarization of the cathodic areas. Such a depolarization should lead to a potential change in the cathodic (positive) direction, as may be seen




Curve I, Work of Hadley; curve II, present work. *A*, Inoculation; *B*, addition of lactate; *C*, second addition of lactate or addition of sulphide

from a consideration of the Evans polarization diagram for a corroding system. We also feel unable to accept the statement that the final steady potential (− 0·370 V., normal hydrogen scale) is due to the establishment of the Fe/FeS/S″ equilibrium, on the grounds that this value is too positive for such an equilibrium. It is, in fact, more positive than the standard $Fe/Fe^{++}$ potential (− 0·441 V.) and would thus imply a concentration of ferrous ions of greater than 1 *M*. Such a concentration seems impossible in the presence of the large amounts of sulphide produced under heterotrophic conditions.

We have, accordingly, carried out further potential measurements. For these experiments we have used electrodes in the form of strips of Armco ingot iron 2·0 cm. × 0·5 cm. × 0·05 cm. in size, immersed, under anaerobic conditions, in about 100 c.c. of the autotrophic medium described elsewhere[2]. After steady potentials had been attained, the medium was inoculated with sulphate-reducing bacteria, and evidence of their activity was obtained in the blackening of lead acetate paper previously placed in the gas space of the culture vessels. At a later stage, sterile sodium lactate solution was introduced, generally in amounts of 100 mgm. of the salt, thus providing an organic hydrogen donor. In this way, we were able to study the influence of bacterial activity on the corrosion potential under autotrophic and under heterotrophic conditions. Our results indicate that there is little or no alteration of the potential on inoculation under autotrophic conditions, but that the introduction of lactate at once brings about the sequence of potential changes observed by Hadley. Further, we have been able to reproduce fairly closely the values of Hadley, both for the most anodic potential reached and for the final steady value. These results are also shown in the graph. We were also able to produce a second, smaller, fall and rise of potential by the introduction of a second portion of lactate and also by the addition of sulphide, applied as a sterile solution of hydrogen sulphide in water, in an amount approximately equivalent to the quantities of lactate used (calculating for oxidation to acetate).

From these results, we conclude that:

(1) Bacterial activity under autotrophic conditions exerts little influence on the corrosion potential. In particular, no significant cathodic depolarization occurs.

(2) The fall in potential which follows the introduction of lactate indicates anodic depolarization and is probably due to the increase in production of sulphide following the addition of the organic hydrogen donor. This is in conformity with the property of sulphide of acting as an anodic stimulator, and suggests that it is to this action that the bacterial stimulation of corrosion under heterotrophic conditions is due.

Permission to publish this note has been granted by the South African Council for Scientific and Industrial Research.

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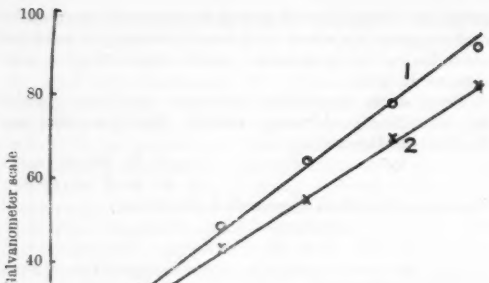
## A Quantitative Fluorescence Test for the Determination of Corticosteroids

Reichstein and Shoppee[1,2] observed that some corticosteroids develop fluorescence by treatment with sulphuric acid. Of the adrenocortical steroids isolated by them, only the α,β-unsaturated ketones, with the exception of 11-dehydrocorticosterone and 11 - dehydro - 17α - hydroxycorticosterone (cortisone), showed this reaction.

A similar fluorescence arising by treatment of natural œstrogens with phosphoric acid, and its application for quantitative determination of those hormones, was described by Finkelstein, Hestrin and Koch[3]. It has also been noted by these authors that 11-deoxycorticosterone, progesterone and testosterone show the same reaction, though to a lesser extent. The fluorescence test was used later for the quantitative determination of œstradiol-17β, (+)-œstrone and œstriol in urine[4,5].

On analysing urine for the above œstrogens, we have observed that it contains a substance (or substances) different from the œstrogens, which also produces fluorescence on treatment with phosphoric acid. On partition of the urinary extracts between ether and *N* sodium hydroxide, this substance enters the neutral fraction; it may also be extracted with water from a benzene–petroleum ether (1 : 1) solution. This behaviour and some clinical observations pointed to a similarity with some corticosteroids and led us to the assumption that the substance responsible is derived from the adrenal cortex[6,7].

In order to carry out the quantitative determination of this material, it seemed to us that the best way would be to compare its fluorescence intensity with those of crystalline corticosteroids, and to record the measurements in terms of one of these. The fluorescence of several corticosteroids has therefore been investigated; treatment of corticosterone, 17α-hydroxycorticosterone, 11-deoxycorticosterone and their respective acetates with 85 per cent phosphoric acid for 15 min. in a boiling-water bath leads to the development of a bluish-green fluorescence. The intensity of the fluorescence is proportional to the concentration of the steroid and shows a linear relationship on being measured in a Farrand fluorometer provided with interference filters with the maximum transmission at 435 mμ in the primary position and 530 mμ in the secondary position. Representative results with corticosterone and 17α-hydroxycorticosterone are shown in the accompanying graph. 11-Dehydro-17α-hydroxycorticosterone (cortisone) and its acetate did not show any fluorescence on treatment with phosphoric acid.




Fluorescence curves of (1) 17 α-hydroxycorticosterone and (2) corticosterone

Recently, Neher and Wettstein[8] have published results on the application of the phosphoric acid fluorescence test to analogues of corticosteroids by means of paper chromatography. In their case the fluorescence was developed by using 15 per cent phosphoric acid. They also tried to carry out the fluorescence test in a test-tube by heating the steroids with 85 per cent phosphoric acid for an hour at 90°; they state that the resultant fluorescence was comparatively weak. This could be explained on the basis of our experiments, which showed that the optimal time of heating to obtain the best fluorescence was 15–30 min., whereas heating for an hour partially destroyed the fluorescence.

It is of interest to note that the fluorogenic substances which Neher and Wettstein were able to record on the paper chromatogram, and which were apparently different from corticosterone and 17α-hydroxycorticosterone, might be identical with the fluorogenic substances of the neutral fraction of our urinary extracts[6,7].

I am indebted to Prof. T. Reichstein, Basle, for the gift of adrenocortical steroids used in this study, to Prof. B. Zondek and Prof. C. W. Shoppee for their interest and helpful advice, and to the Humanitarian Trust for support.

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## Observations on the Rate of Incorporation of Phosphorus-32 into Adenosine Triphosphate in Skeletal Muscle

Furchgott and Shorr[1] and Kalckar *et al.*[2] have pointed out the importance of differentiating between intra- and extra-cellular inorganic phosphorus in the determination of the turnover-rates of adenosine triphosphate and phosphocreatine. This arises particularly in a tissue such as skeletal muscle, where the inorganic phosphorus of the extracellular fluid does not come into rapid equilibrium with that of the intracellular fluid. The perfusion technique of Kalckar *et al.*[2] is believed by these authors to eliminate the extracellular phosphorus, but to have no effect on the specific activity of the intracellular adenosine triphosphate and phosphocreatine. The experimental support for this belief[2] rested on an experiment in which one hind limb of a rabbit was removed after the injection of phosphorus-32 and placed in an ice bath for the time period over which the remaining hind limb was perfused with 1–1·5 l. of phosphate-free Ringer's fluid. Subsequent analysis of the extracts from the muscles of the two hind limbs revealed identical specific activities in adenosine triphosphate and phosphocreatine. The conclusion that no change occurred in the specific activities in the perfused limb is based on the assumption that no change occurred in the control limb, which was kept in the ice-bath.

It occurred to us that there are no grounds for such an assumption, and we have repeated the rabbit experiments described by Kalckar *et al.*[2] with one modification. On removal of the control limb 15 min. after the injection of phosphorus-32, we have divided the thigh muscles into two portions, one of which was placed in ice and the other dropped into liquid oxygen. At the end of the perfusion, the muscles were removed from the perfused limb and dropped into liquid oxygen together with those which had been kept in ice. Trichloracetic acid extracts were made in the usual way, neutralized and the specific activities of the inorganic phosphorus and the phosphorus released from the purified nucleotides by myosin hydrolysis determined as described by Ennor and Rosenberg[3].

Comparison of Specific Activities of Inorganic Phosphorus and Terminal Group of Adenosine Triphosphate in Perfused Hind Limb and Non-perfused Hind Limb of the Rabbit. Muscles from latter divided into half—one half into liquid oxygen and the other half into ice-bath. Left hind limb removed 15 min. after and perfusion of right hind limb commenced 20 min. after the injection of phosphorus-32

| Fraction | Right hind limb, thigh muscles | Left hind limb, thigh muscles | |
|---|---|---|---|
| | Perfused | Liquid oxygen | Ice |
| Inorganic phosphorus | 15·7 | 55·5 | 30·4 |
| Terminal group of adenosine triphosphate | 10·1 | 16·1 | 11·5 |

It will be noted that perfusion produces a marked fall in the specific activity of inorganic phosphorus and also, as has been found earlier[2], the specific activity of the terminal phosphorus group of adenosine triphosphate of the perfused muscle is close to that of the muscle retained in ice. However, the specific activity of the terminal group of adenosine triphosphate present in the muscle stored in liquid oxygen is considerably higher than in the other two cases. This indicates that a turnover of adenosine triphosphate has occurred in both the muscle stored in ice and in the perfused muscle.

These results thus vitiate the experimental work of Kalckar *et al.*[2] and Furchgott and Shorr[1], and make it clear that unless metabolic reactions are stopped—by immersion of tissues in liquid oxygen—the results obtained will be of questionable value. This follows from the speed with which intracellular reactions occur even at low temperatures and under predominantly anaerobic conditions.

One other point raised by the above results is worthy of note. The fact that the specific activity of inorganic phosphorus in the ice-stored muscle is lower than that in the muscle stored in liquid air can only indicate dilution of the inorganic pool by phosphorus of low specific activity arising as a result of the breakdown of weakly labelled organophosphates. The incorporation of this phosphorus into adenosine triphosphate then explains the drop in specific activity of the terminal phosphorus group. Such a breakdown and incorporation must then occur during perfusion, and it may be inferred that the true intracellular inorganic phosphorus must have a higher specific activity than that actually measured in the perfused muscle. Experiments designed to determine the true turnover-rate of each of the phosphorus groups of adenosine triphosphate and of phosphocreatine are in progress and will be reported in due course.

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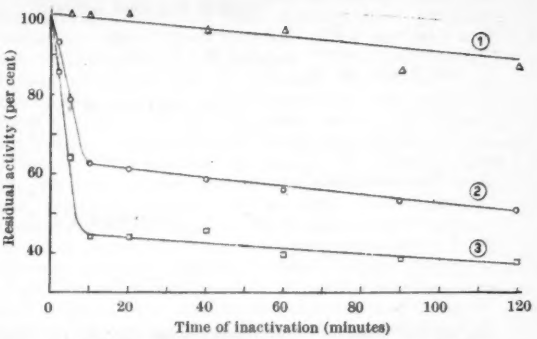
## Differentiation of the Polygalacturonases of *Aspergillus niger*

It has been long known that there is no close relationship between the physically and chemically measured action of polygalacturonase[1]. Jansen and MacDonnel[2], Matus[3], McColloch and Kertesz[4], Reid[5], Schubert[6] and others have, from very different observations, suggested that the polygalacturonase preparations extracted from micro-organisms and plants contain more than one glycosidically effective pectin enzyme.

In the course of an investigation of the extracts from *Aspergillus niger*, we have been able to show with certainty at least four different polygalacturonases in the same culture extract. We heated a culture liquid of *A. niger* containing polygalacturonase at *p*H 4·2 to 50° C. and determined at certain time-intervals the remaining residual activity by three different methods, namely: (1) reduction in viscosity of a freshly prepared pectin-containing apple juice; (2) reduction in viscosity of a 0·5 per cent solution of commercial apple pectin[6]; and (3) formation of aldehyde on pectate[6].

The results are shown in the accompanying graph. This shows that the reduction of activity during heat-inactivation differs according to the method of determination employed. The activity on apple juice is almost unaffected, whereas the measurements by the two other methods give significant losses of activity during the first few minutes; then, however,




Inactivation of polygalacturonase from *A. niger*. Inactivation temperature, 50° C. *p*H, 4·2. Curve 1, reduction of viscosity in apple juice; curve 2, reduction of viscosity in artificial pectin solution; curve 3, aldehyde formation

the activities remain nearly constant. These observations show that the pectinase examined cannot contain a single polygalacturonase, but that it must contain at least two parts, the first one unstable at *p*H 4·2 and 50° C. and the second one stable under these conditions. The unstable part has no effect on the natural pectin in the apple juice and needs for the same reduction of viscosity on 'artificial' pectin solution nearly twice as many scissions as the stable part.

We were able to differentiate further the second part at *p*H 0·8 and 30° C. Under these conditions, the inactivation stops practically at a residual activity of about 35 per cent. The remaining polygalacturonase-containing solution has no effect on apple juice. The enzyme acting on natural pectin, on the other hand, could be separated from the original solution or from the pectinase solution treated at *p*H 4·2 and 50° C. with fuller's earth, at *p*H 4·2. The fuller's earth absorbs all the polygalacturonase except that which is responsible for the degradation of the natural pectin in apple juice. The inactivation curve at 60° C. and *p*H 4·2 of the polygalacturonase solution treated with fuller's earth shows the uniform-

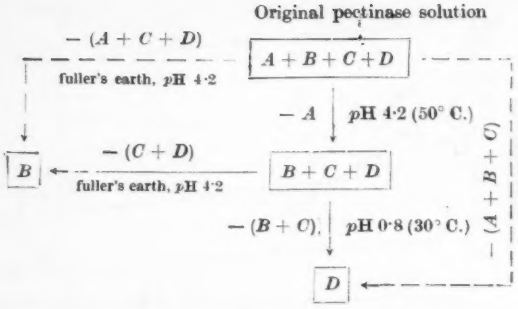
Table 1. Inactivation of Polygalacturonase *B* at 60° C. and *p*H 4·2

| Times of heating (min.) | % Activity measured | | |
|---|---|---|---|
| | Viscosity reduct. in apple juice | Viscosity reduct. in artificial pectin solution | Aldehyde formation |
| 0 | 100 | 100 | 100 |
| 10 | 89·7 | 87·5 | 87·7 |
| 20 | 73·7 | 73·1 | 73·8 |
| 42 | 56·1 | 53·8 | 53·8 |
| 60 | 41·7 | 42·5 | 41·9 |
| 90 | 26·9 | 26·6 | 27·0 |
| 120 | 17·3 | 18·8 | 18·8 |

Table 2. Some Properties of the Four Polygalacturonases Differentiated from *A. niger* Culture Liquid

| Poly-galact-uronase | Stability at | | Activity based on | | Half-time tempera-ture* |
|---|---|---|---|---|---|
| | *p*H 4·2 (50° C.) | *p*H 0·8 (30° C.) | Viscosity reduct. in apple juice | Viscosity reduct. in artificial pectin solution (%) | |
| *A* | unstable | unstable | none | 45 | < 45° C. |
| *B* | stable | unstable | full | 25 | 60° C. |
| *C* | stable | unstable | none | 13 | > 50° C. |
| *D* | stable | stable | none | 17 | 55° C. |

* The half-time temperature is the temperature at which the activity at the optimum *p*H of stability falls during 60 min. to 50 per cent of its original activity (ref. 7).




ity of the present polygalacturonase (Table 1). The activities diminish in the same manner when determined by the three methods mentioned above. The above scheme and Table 2 show some properties of the four polygalacturonases *A*, *B*, *C* and *D*.

E. Schubert

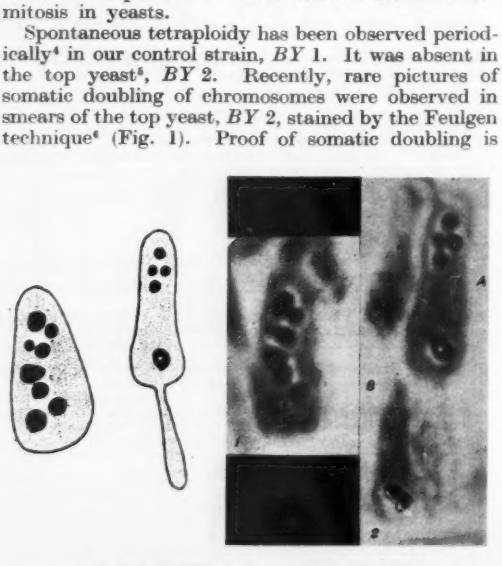
Swiss Ferment Company, Ltd.,
Basle.
Dec. 20.

[1] Kertesz, Z. I., *J. Amer. Chem. Soc.*, **61**, 2544 (1939).
[2] Jansen, E. F., and MacDonnel, L. R., *Arch. Biochem.*, **8**, 97 (1945).
[3] Matus, J., *Ber. Schweiz. Bot. Ges.*, **58**, 319 (1948).
[4] McColloch, R. J., and Kertesz, Z. I., *Arch. Biochem.*, **17**, 197 (1948).
[5] Reid, W. W., *Nature*, **166**, 76 and 569 (1950).
[6] Schubert, E., *Schweiz. Brauereirundschau*, **62**, 39 (1951).
[7] Schubert, E., *Textilrundschau*, **5**, 1 (1950).

## Critical Evidence for Somatic Doubling of Chromosomes in a Top Yeast

Tetraploidy was induced in our 2-chromosome control strain by treatment with acenaphthene[1]. As an off-shoot of this experiment, we were able to isolate a top yeast, *BY* 2, which was diploid but had a pair of unequal chromosomes[2]. This inequality rendered it possible to offer critical evidence[3] for mitosis in yeasts.

Spontaneous tetraploidy has been observed periodically[4] in our control strain, *BY* 1. It was absent in the top yeast[5], *BY* 2. Recently, rare pictures of somatic doubling of chromosomes were observed in smears of the top yeast, *BY* 2, stained by the Feulgen technique[6] (Fig. 1). Proof of somatic doubling is afforded by a demonstration of an anaphase of the doubled complement. Fig. 1 shows such an anaphase. The eight chromosomes appear in two groups, the one at the top showing two small and two large bodies. In the lower group, this size difference is not apparent, probably due to the swelling preceding a telophasic reconstitution. We should like to emphasize here that there is no strict synchronization in the timing of karyokinesis and cytokinesis.




The cells in Figs. 1 and 2 *A* are 5·1 $\mu$ long

This lack of correlation would become obvious in the cell *A* in Fig. 2, in which there is a reconstituted nucleus at one end near the bud, while the four chromosomes are lying free at the other end. At *B* in the same photograph is a normal diploid early metaphase with two unequal chromosomes.

The mere fact that there is a somatic doubling does not entitle one to conclude that stable tetraploids could be isolated. Temporary somatic doubling may be followed by multipolar budding. The isolation of stable tetraploids depends on the primary condition that a doubled complement of chromosomes should be able to function harmoniously. Somatic doubling is thus only one of the conditions requisite for induction of tetraploidy. A gene mutation appears to be necessary to render the doubled complement a stable unit[7].

Our earlier claim of spontaneous and induced tetraploidy in yeasts does not appear to have been well received[8]. The main criticism is that we have not carried out crossing tests. Winge employed strains of unknown chromosomal constitution in his genetical investigations, but yet interpreted his results assuming them to be diploids. The mere isolation of spores and a study of their segregation ratios will not justify radical claims if the cytology of the strains has been ignored. The occurrence of spontaneous and induced tetraploidy in yeasts makes it necessary to know whether the spores isolated belong to diploids or to polyploids. The photographs presented here offer proof that somatic doubling of chromosomes is as common in yeasts as in higher plants.

Saraswathy Royan
M. K. Subramaniam

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Department of Biochemistry,
Indian Institute of Science,
Bangalore 3. Dec. 3.

[1] Subramaniam, M. K., *Curr. Sci.*, **14**, 234 (1945); *Proc. Nat. Inst. Sci., India*, **13**, 129 (1947).
[2] Subramaniam. M. K., and Ranganathan, B., *Nature*, **157**, 49 (1946); *Proc. Nat. Inst. Sci. India*, **14**, 279 (1948).
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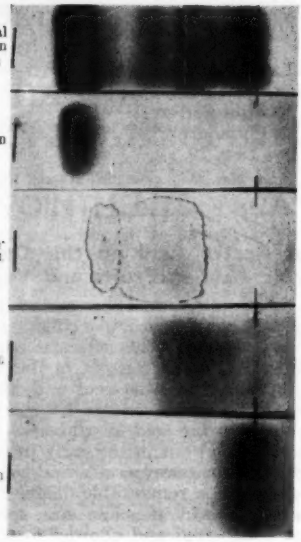
[5] Subramaniam, M. K., and Ranganathan, B., *J. Sci. and Indust. Res.*, **9B**, 4 (1950).
[6] Subramaniam, M. K., *Proc. Nat. Inst. Sci., India*, **14**, 315 (1948).
[7] Subramaniam, M. K., and Sreepathi Rao, S. K., *Research*, **3**, 49 (1950).
[8] Winge, Ö., *C.R. Lab. Carlsberg, Ser. Physiol.*, **25**, 85 (1951).

## Lyophilic Properties of Isolated Serum-Protein Fractions

Electrophoresis on paper of serum proteins has enabled us to separate small quantities into albumin, and α-, β- and γ-globulin. By using a comparatively thick filter paper (Munktell Nr. 20, Grycksbo, Sweden), 58 cm. × 7 cm., we can separate up to 30 mgm. of protein within 24 hr., with 5·5 V./cm. and 16–18 m.amp. applied in a closed atmosphere. As buffer system veronal/veronal sodium is used, of 0·06 ionic




strength and *p*H 8·9. From the two paper strips used simultaneously, only one is stained afterwards with bromphenol blue; this strip serves as a guide for cutting off the fractions from the still wet, unstained strip.

The protein is eluted from the cuttings with physiological saline, as indicated by Dent *et al.*[1]; the eluted fractions of six runs are united and concentrated by dialysis against 10 per cent dextran in the cold, until the volume of the protein sols is reduced to about 3 c.c. The purity of such fractions is controlled by electrophoresis on paper. 0·06 c.c. of each fraction is put on a paper strip, 32 cm. × 7 cm. After 8 hr. with 4·4 V./cm. and 7–8 m.amp. applied, the serum fractions move as shown in the accompanying photograph; for comparison the results for the original normal human serum are also shown.

We often find that the $\alpha_2$-globulins are overlapping the position of the β-globulins when they run separately; we believe that their mobility is somewhat accelerated if they run together with albumins. In order to compare the hydrophilic and lipophilic properties of the serum fractions, we are using animal skin membranes ('Naturin', Sweden), which we have previously stained with Evans blue and with Sudan red in a standardized manner[2]. Little disks of 3 cm. diameter of this skin are placed in Petri dishes and carefully submerged in 4 c.c. of 0·8 per cent solutions of the protein fractions in physiological saline. Each day the membranes are turned. After 72 hr. in the refrigerator at 2° C., the dyestuff content is determined in the Beckman spectrophotometer model *DU*. Solutions with Evans blue are measured at the wave-length 610 mμ and those of Sudan red at the wave-length 500 mμ, and they are compared against uncoloured fractions.

| 0·8 per cent solutions of | Elution (in γ) of dye per mgm. protein after 72 hr. at 2° C. Evans blue | Sudan red |
|---|---|---|
| Albumin | 56 | 9·5 |
| α-Globulin | 22 | 10·1 |
| β-Globulin | 35 | 11·3 |
| γ-Globulin | 18 | 5·4 |

The figures in the accompanying table, which are the average results of four elutions, have extreme variations with Evans blue of ± 1·4 per cent and with Sudan red of ± 2·2 per cent. They show that the hydrophilic properties of albumin, as measured by the elution of Evans blue, is much the best, followed by β-globulin. In the lipophilic sector, the lipoid-carrying α- and β-globulins range slightly above the albumin. The lyophilic properties of γ-globulin are the weakest. These findings are well in accord with our previous results with human blood serum. Basing our knowledge on the action of serum alone, we have stated that the lytic properties depend on albumin and the α- and β-globulins[3]. As the quantities of protein which can be easily separated on paper are also sufficient for serological reactions and tests of lability, we suggest that the practical possibilities of the preparative side of electrophoresis on paper are considerable.

CH. WUNDERLY

Medical University Clinic,
Zurich.
Dec. 20.

[1] Dent, C. E., Stepka, W., and Steward, F., *Nature*, **160**, 682 (1947)
[2] Wunderly, Ch., *Nature*, **165**, 850 (1950); *Kolloid-Z.*, **117**, 137 (1950).
[3] Wunderly, Ch., and Wuhrmann, F., "Liver Disease", CIBA Foundation Symp., London, 1951, 11f.; *Schweiz. Med. Wschr.*, **81**, 1102 (1951).

## Inhibition of Development of *Trichostrongylus retortæformis*

RETARDED or arrested development of nematodes has been recognized as one of the effects of host resistance for some time. In the course of our studies of resistance to infections of *Trichostrongylus retortæformis* in rabbits, we have encountered this phenomenon again.

When a massive dose of infective larvæ is administered to a previously infected animal, a large proportion of the larvæ, having burrowed into the intestinal mucosa, are there inhibited in their development and, instead of returning to the lumen of the intestine and continuing their development, they remain between the glands of the mucosa. These worms are in the late third larval stage, and when recovered from the mucosa are seen to possess a characteristic deliberate burrowing movement entirely unlike that of the free-living third stage.

These dormant larvæ may remain in the mucosa for long periods of time, and we have recovered them alive and active up to 98 days after re-infection. The numbers that may be recovered from the mucosa decrease with time. While 35,000 late third-stage larvæ may be recovered a fortnight after re-infection with 100,000 larvæ, the number will have dwindled to a mere 2,000 after three months, and none can be recovered after a year.

One of the reasons for this decrease appears to be that these dormant worms resume their development when the resistance of the host declines. They may all resume their development together, as much as ten weeks after infection, and cause the death of the host. More commonly, however, they appear to develop in relays. The fæcal egg-count rises fairly rapidly, and after a short time falls to zero just as rapidly. After remaining at zero for a fortnight or so, this sequence of events is repeated, and the periodic appearance and disappearance of worm eggs in the fæces may continue for months as successive

groups of worms develop to maturity and in so doing evoke the self-cure mechanism which, while it leads to the expulsion of the adults, does not appear to affect the dormant larvæ.

If these phenomena occur in infections of other members of the Trichostrongylidæ, they would appear to have an important relevance to the epidemiology of parasitic gastro-enteritis of ruminants.

J. F. Michel

Veterinary Laboratory,
New Haw,
Weybridge, Surrey.
Jan. 1.

## Occurrence of *Pelagia* in the River Yealm Estuary, South Devon

The scyphomedusan *Pelagia* was observed in some numbers in the River Yealm estuary, South Devon, on December 20, 1951. This is of more than merely faunistic interest, though on that score alone it is worthy of note, since the genus is purely pelagic and, so far as I am aware, has never before been recorded in the English Channel nearer inshore than the neighbourhood of the Eddystone, and then only very sparsely[1]. The present record is due to the vigilance of Miss Agnes Russell, of the yacht *Ardglass* moored in the Yealm estuary, who saw a specimen of the medusa as she was rowing ashore from her yacht; though not a biologist, she was quick to recognize its unfamiliar pattern and that, in any event, a 'jelly-fish' in December was a matter for further inquiry.

Miss Russell brought the specimen to this laboratory, where it was identified as *Pelagia*, a genus under which many different species have been described that may be no more than forms of the one species *Pelagia noctiluca* Péron et Lesueur. A further search was then made, resulting in the finding of some sixty specimens, all close to the edge of the strand, some near the mouth of the estuary and some in Newton Creek where the first one was taken, which is almost a mile from the open sea. All when captured were exhibiting swimming movements of the bell, varying in degree from feeble and sporadic contractions in some to vigorous rhythmic pulsations in others. The size in diameter of the bell ranged from about an inch to 3–4 in., the majority being about 2 in. Pigmentation was not examined in detail but was in two main colours, a golden brown, distributed as a speckling over the surface of the bell, and a mauve, characteristic more particularly of the gonadial elements, which in the larger specimens were well developed. The specimens were kept alive overnight in circulating sea water and were then removed to the laboratory of the Marine Biological Association at Plymouth. When mechanically stimulated in the dark, most of them had shown faint luminescence which, in the case of the more vigorous, was sufficient to outline momentarily the shape and pattern of the whole animal. Handling produced stinging sensations, which were not lasting and only noticeable on the more tender areas of the skin such as between the fingers.

The further interest of this occurrence is as a contribution to data concerning the movement of Atlantic water into the English Channel. Russell[1], who recorded this medusa from Channel stations, regarded its presence there as indicating an influx of water of oceanic origin.

O. D. Hunt

Research Laboratory (Biological),
International Paints, Ltd.,
Newton Ferrers,
Plymouth.
Dec. 29.

[1] Russell, F. S., *J. Mar. Biol. Assoc.*, **22**, 417 and 497 (1938).

## Effect of Acetic Acid on the Oxidation of Ascorbic Acid in Fruits and Vegetables

It has been established by earlier investigators that acetic acid has a destructive effect on the ascorbic acid in raw cabbage. This effect is somewhat surprising, since the lower the *p*H in the medium, the more stable is the ascorbic acid and, therefore, one would expect the acetic acid to have a preservative effect on the ascorbic acid in cabbage. However, in experiments carried out in the early months of 1951, we found that, in many fruits and vegetables, the ascorbic acid is to a remarkable degree oxidized into dehydroascorbic acid if slices are sprinkled with 5 per cent acetic acid and allowed to stand for two hours. This oxidation does not take place if water is used instead of acetic acid. Other lower fatty acids have a similar effect. The action of lactic acid is very slow and that of citric and tartaric acid practically negligible.

In fruits and vegetables possessing only weak resistance against the oxidation of ascorbic acid, the effect of acetic acid is most pronounced. Thus, in cabbage, cucumber, horse-radish, carrot, potato, lettuce, dill, leek, apple, pear and banana, 60–90 per cent of the ascorbic acid is oxidized. In parsley, spinach, cauliflower and tomato, the corresponding values are 20–50 per cent, and in orange and onion, only 0–10 per cent.

We conceive the effect to be similar to that caused by mechanical damage to the cells. The acid penetrates into the cells and the hydrogen ions bring about a disturbance of the balance between the oxidizing and the reducing enzyme systems of the cell.

F. Alm

Swedish Institute for Food
Preservation Research,
Gothenburg.
Dec. 15.

## Transitions in the Chromium–Manganese and Nickel–Vanadium Sigma Phases

Transitions occur in the chromium – manganese sigma phase at 1,005° C. and in the nickel – vanadium sigma phase [see *Nature*, January 12, 1952, p. 70] at a temperature below 800° C. In both these systems the structure present above the transition temperature has been investigated by high-temperature camera photographs. The films show that the same main X-ray reflexions are given by the high-temperature phase as are observed at room temperature. Alloys quenched from the high-temperature phase regions do not show decomposed microstructures. The transitions may be of the order-disorder type.

W. B. Pearson

Inorganic Chemistry Laboratory,
Oxford. Nov. 30.

# FORTHCOMING EVENTS

## Thursday, June 5

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Scientific Papers.

## Friday, June 6

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. G. I. Finch, F.R.S.: "Man at High Altitudes".

# APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER (Grade II) IN GEOLOGY—The Registrar, The University, Bristol (June 7).

LECTURERS (2) IN MATHEMATICS—The Registrar, King's College, Newcastle-upon-Tyne (June 7).

RESEARCH ASSISTANT (honours graduate in biochemistry or chemistry) to work on problems of the metabolism of pathogenic fungi—The Registrar, The University, Leeds 2 (June 7).

SENIOR LECTURER IN ELECTRICAL ENGINEERING, and a TEACHER OF ENGINEERING DRAWING—The Principal, Royal Aircraft Establishment Technical College, Farnborough, Hants (June 7).

ASSISTANT LECTURER IN ZOOLOGY—The Registrar, The University, Manchester 13 (June 11).

SENIOR AND JUNIOR FELLOWSHIPS—The Director, Atomic Energy Research Establishment, Harwell, Didcot, Berks (June 12).

ASSISTANTS IN THE DEPARTMENT OF BOTANY (research interests in morphology and anatomy of angiosperms desirable)—The Secretary, The University, Aberdeen (June 14).

JUNIOR LECTURER IN MATHEMATICS in the University of Oxford—Prof. E. C. Titchmarsh, Mathematical Institute, Radcliffe Science Library, Oxford (June 14).

LECTURER IN BIOCHEMISTRY in the Department of Physiology, and an ASSISTANT LECTURER (with an honours degree) IN PHILOSOPHY—The Registrar, King's College, Strand, London, W.C.2 (June 14).

SENIOR LECTURER IN THE DEPARTMENT OF TEXTILE INDUSTRIES—The Registrar, College of Technology, Manchester 1 (June 16).

SENIOR AND JUNIOR FELLOWSHIPS for fundamental research in experimental or theoretical physics, or in electronics—The Chief Superintendent, Telecommunications Research Establishment, Malvern, Worcs (June 16).

ASSISTANT LECTURER (with a good honours degree in mathematics or in engineering) IN MATHEMATICS AND ENGINEERING—The Registrar, The University, Manchester 13 (June 18).

GRADUATE with an honours degree in biochemistry, or with similar qualification and research experience, and a GRADUATE with honours degree in organic chemistry, and research experience, preferably in synthetic work, IN THE BIOCHEMISTRY DEPARTMENT—The Secretary, Hannah Dairy Research Institute, Kirkhill, Ayr (June 20).

RESEARCH FELLOWSHIPS IN THE DEPARTMENT OF MATHEMATICAL PHYSICS—The Secretary, The University, Birmingham 15 (June 20).

ASSISTANT LECTURER IN BOTANY (a special interest in mycology is desirable)—The Registrar, University College, Cathays Park, Cardiff (June 21).

TUTORIAL STUDENTSHIPS IN BOTANY, ELECTRICAL ENGINEERING, GEOLOGY, MATHEMATICS, PHYSICS, PHYSIOLOGY (Biochemistry)—The Registrar, King's College, Strand, London, W.C.2 (June 21).

BENNINGTON MEMORIAL STUDENTSHIP for anthropometric or craniological research bearing upon the problem of evolution—The Secretary, University College, Gower Street, London, W.C.1 (June 22).

CHAIR OF ENGINEERING in University College, Dundee—The Secretary, The University, St. Andrews (June 23).

SENIOR RESEARCH OFFICER or RESEARCH OFFICER, to carry out research in mathematical statistics—The Secretary, Institute of Statistics, 13 Norham Gardens, Oxford (June 23).

CHAIR OF PHYSICS, and LECTURERS (3) IN PHYSICS, in the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (June 24).

PRINCIPAL SCIENTIFIC OFFICER (with a first- or second-class honours degree in a science subject, or equivalent qualification, and who should be a mineralogist or inorganic chemist with experience in the utilization of minerals or ores) IN THE INTELLIGENCE DIVISION of the Department of Scientific and Industrial Research—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4144/52 (June 26).

LECTURER IN MATHEMATICS at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (June 30).

ASSISTANT LECTURER IN THE DIVISION OF CHEMISTRY AND PHYSICS in the Department of Physiology—The Secretary, Royal Veterinary College and Hospital, Royal College Street, London, N.W.1 (July 1).

DEPUTY DIRECTOR OF THE INSTITUTE, and a CHIEF ASSISTANT FOR POTATO INVESTIGATIONS—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge (July 1).

SENIOR AND JUNIOR FELLOWSHIPS—The Director, Royal Aircraft Establishment, Farnborough, Hants (July 15).

LECTURERS (2) IN THE DEPARTMENT OF CIVIL ENGINEERING, University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Cape Town, July 18).

PRINCIPAL RESEARCH OFFICER or SENIOR RESEARCH OFFICER, Coal Research Section of the Commonwealth Scientific and Industrial Research Organization, Sydney, to carry out investigations into the coke-gas and by-product-making properties of Australian coals, and to be responsible for the work of the Section dealing with the carbonization of coal—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 3844 (July 19).

LECTURER IN ZOOLOGY at New England University College (University of Sydney), Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 31).

ASSISTANT (Grade B) IN THE DEPARTMENT OF CHEMISTRY (preferably with special qualifications in organic chemistry), Bradford Technical College—The Director of Education, Town Hall, Bradford.

BIOCHEMIST or CHEMIST interested in biological problems, to assist in research on milk proteins and enzymes—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 52/6.

ENTOMOLOGIST in the Forest Department, Kenya (duties include the study of forest insects of Kenya with special reference to pests of softwood plantations)—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting Ref. No. 27040/89/52.

GEOCHEMIST (with an honours degree in chemistry, and specialized in inorganic and physical chemistry), in Tanganyika—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting 27106/47/52.

LECTURER IN GEOPHYSICS in the Department of Physics—Prof. W. H. Watson, McLennan Laboratory, University of Toronto, Toronto 5, Canada.

PRINCIPAL SCIENTIFIC OFFICER (with a first- or second-class honours degree in engineering, physics or mathematics; considerable experience in experimental aerodynamics, including wind tunnel work, is essential) to take charge of two new low-speed wind tunnels at a Ministry of Supply establishment in Bedfordshire—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting C.303/52A.

# REPORTS and other PUBLICATIONS

*(not included in the monthly Books Supplement)*

## Great Britain and Ireland

Manchester Joint Research Council. Annual Report for 1951 and Report to the Council by the Executive Liaison Officer. Pp. 12. (Manchester: Manchester Joint Research Council, 1952.) [74

Pest Control Farmers' Handbook. Tenth edition. Compiled by Dr. W. E. Ripper, A. L. Abel, Dr. R. M. Greenslade, S. G. Jary and R. W. Shorrock. Pp. 104. (Cambridge: Pest Control, Ltd., 1952.) [74

Department of Scientific and Industrial Research: Technical Information and Documents Unit. A Bibliographical Survey of German and Japanese Experience in the Extraction of Low-Grade Non-Ferrous Ores and the Recovery of Non-Ferrous Metals and Compounds. (Report No. RMS-3.) Pp. vi+100. (London: H.M. Stationery Office, 1952.) 3s. 6d. net. [74

Department of Scientific and Industrial Research: Road Research Laboratory. Road Research Technical Paper No. 24: The Suction of Moisture held in Soil and other Porous Materials. By D. Croney, J. D. Coleman and Pamela M. Bridge. Pp. vi+42+2 plates. (London: H.M. Stationery Office, 1952.) 2s. net. [94

Proceedings at a Symposium on Welding and Riveting Larger Aluminium Structures, Claridges, London, W.1, November 1951. Pp. 224. (London: Aluminium Development Association, 1952.) [94

Society for Freedom in Science. Occasional Pamphlet No. 12: The Psychological Connexion of Two Basic Principles of the Society for Freedom in Science. By A. G. Tansley. Pp. 8. (Oxford: Society for Freedom in Science, 1952.) 6d. [164

British Iron and Steel Research Association. Annual Report of Council, 1951. Pp. 120. (London: British Iron and Steel Research Association, 1952.) [164

The Selection of University Students. By F. W. Warburton. (Publications of the University of Manchester School of Education, No. 1.) Pp. vii+46. (Manchester: Manchester University Press, 1952.) 4s. 6d. [164

Anti-Locust Memoir 4: Seasonal Breeding and Migrations of the Desert Locust (*Schistocerca gregaria* Forskål) in North-Eastern Africa and the Middle East. By D. E. Davies. Pp. 57. (London: Anti-Locust Research Centre, British Museum (Natural History), 1952.) 12s. 6d. [174

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 885, Vol. 244: The Evaluation of Zeros of High-degree Polynomials. By F. W. J. Oliver. Pp. 385–415. 7s. 6d. No. 886, Vol. 244: The Stress Distribution near a Loading Point in a Uniform Flanged Beam. By E. W. Parkes. Pp. 417–467. 12s. No. 887, Vol. 244: The Oblique Reflexion of Long Wireless Waves from the Ionosphere at Places where the Earth's Magnetic Field is regarded as Vertical. By J. Heading and R. T. P. Whipple. Pp. 469–503. 8s. (London: Cambridge University Press, 1952.) [174

British Non-Ferrous Metals Research Association. Thirty-second Annual Report. Pp. 66. (London: British Non-Ferrous Metals Research Association, 1952.) [214

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